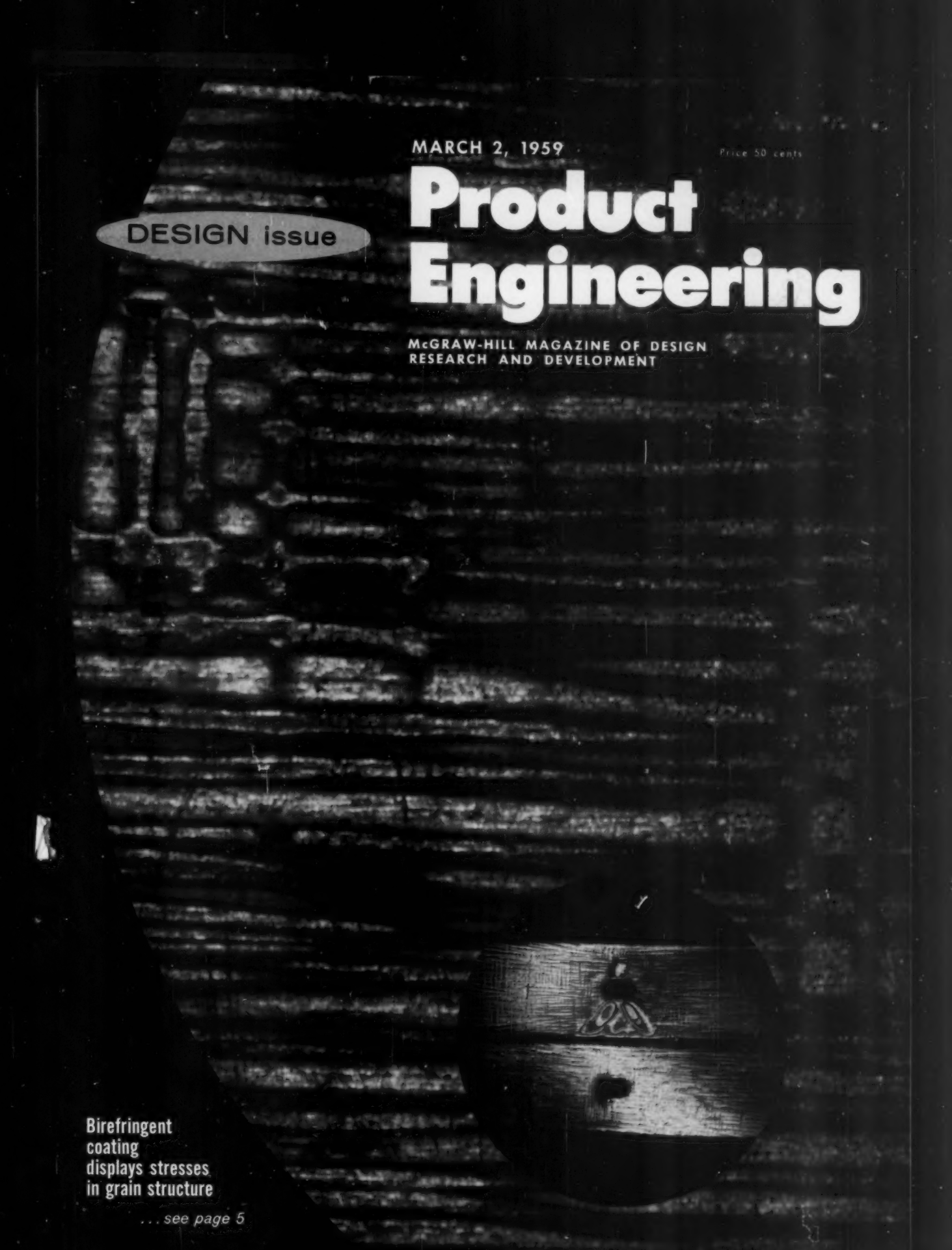


MARCH 2, 1959

Price 50 cents

DESIGN issue

Product Engineering

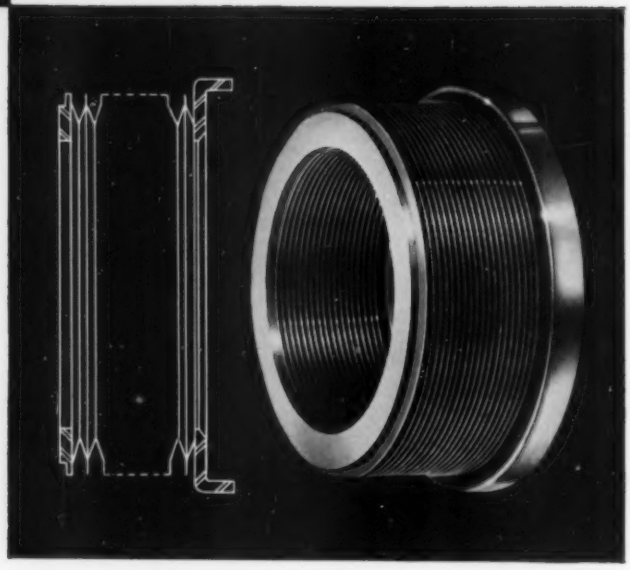
McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

Birefringent coating displays stresses in grain structure

. . . see page 5

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1237 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

SWEET KISSES FOR SWEET CHARITY
PRESS BOTH SIDE BUTTONS AT THE SAME TIME TO RAISE SEPARATING SCREEN
KISSES $1.00
KISSES $1.00

What? Air Polices the Hands Off Policy!

We are not serious, but—

The boys might forget that a kiss doesn't involve the hands but this circuit doesn't. The screen takes care of this. When both his hands depress the actuator buttons, they start the sequence to lift the screen, but "sneaking" one hand off calls for the screen to again guard Miss "Belle-of-the-Bazaar." Our society is pretty romantic so we doubt if this "automatic bolster" will ever become popular. But as a safety feature on presses, brakes and shears the Ross non-tie-down valve, designed to keep both the operator's hands occupied, should become popular.

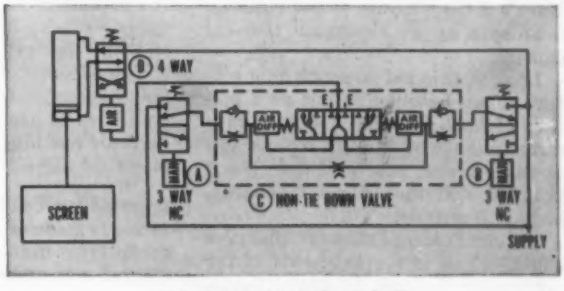
If you are interested in "two-hand safety" you are interested in a Ross non-tie-down valve.

If the operator follows instructions, then two three-way valves, either in series or in parallel, can protect his hands to a degree; but the *operator* who sets his mind to it, can beat either of these hook-ups and keep one hand free. This valve is designed to avoid one hand operation. In the Ross non-tie-down circuit, both three-way button valves are depressed at once to initiate an action and both released before another action can be initiated.

Ross OPERATING VALVE CO.

114 E. Golden Gate Ave. • Detroit 3, Michigan

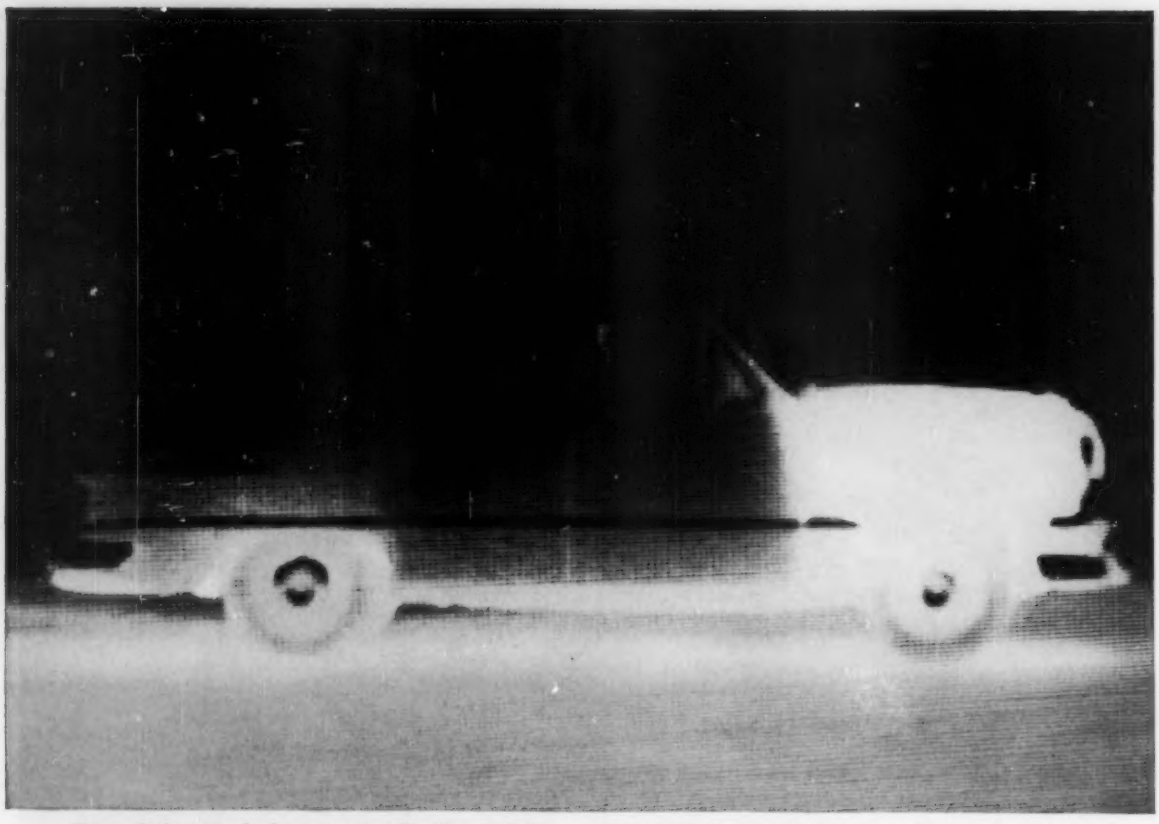
The Ross non-tie-down valve is just one of the many designed by Ross to assist in creating safer press circuits. Call your nearby Ross engineer or write for full details.



SEQUENCE OF OPERATIONS

- Operating valves "A" and "B" simultaneously permits air to flow through the valve "C", shifting valve "D". Valve "D" operates cylinder raising screen.
- De-actuating valves "A" and "B" simultaneously de-actuates valves "C" and "D". Cylinder retracts and valve "C" re-sets itself for another cycle.
- Operating either valve "A" or "B" independently will *not* cause valve "C" to pass actuating air to valve "D".
- De-actuating either valve "A" or "B" independently, causes pilot air to valve "D" to be exhausted through valve "C". After that occurs both valves "A" and "B" must be released to re-set valve "C" before it will pass air to valve "D" again.

CIRCLE 101 READER SERVICE CARD



Thermal photography has many applications to industrial problems involving study of temperature distribution over large or small areas. Camera is produced by Barnes Engineering Company, Stamford, Conn.

New infrared camera gives designers...

a candid picture of heat

Here's a car with its motor running – as seen by an electronic thermal camera.

Look at this not so much as a picture of an automobile but as a picture of *heat*. For that's what it is – a candid shot telling the trained eye exactly *where, how* and *how much* heat is distributed about engine, body and chassis.

Thermal camera photographs give engineers an important new tool for evaluating designs. Of many kinds. In many fields.

How thermal camera works. All warm objects radiate infrared energy. A "detector" inside the camera converts this heat radiation into an electrical signal. It is amplified by tubes containing Nickel... processed ... pictured on film. Cool areas appear black; higher temperatures show up lighter.

The detector, more than any other single component, determines the capabilities of the camera. The ideal detector has high sensitivity ... low electrical noise level... fast response.

Extremely efficient. The infrared detector is made of a thin flake of semiconductor material composed of Nickel and other oxides called a "Thermistor". This type of semiconductor was originated by the Bell Telephone Laboratories. These oxides absorb infrared rays and the resulting minute change in temperature causes an appreciable change in electrical resistance. Sensitivity is further increased by forming the flake razor-edge thin. (And even then, platinum contact wires are readily bonded to it!)

The use of Nickel in the infrared detector is another example of the efficiency and adaptability of this important element. Be sure to investigate Nickel compounds and Nickel alloys whenever you are faced with a problem calling for unusual electrical or electronic properties ... or when you need one with superior ability to withstand destructive service conditions. And don't hesitate to call on Inco for any technical data or other help you need.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street INCO New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

MARCH 2, 1959 Vol. 30, No. 9

PhotoStress Test Shows You the Strain * 43... Dr. Felix Zandman, Tatnall Measuring Instruments Co.
Color photos demonstrate how the author's method works and what you see when reading strains in actual structures and parts under load. Article is sequel to first published report on PhotoStress—in our Sep 1956 issue.

Predicts Cavitation in Pumps 47... W E Wilson, Harvey Mudd College
When using positive-displacement pumps, why risk noisy operation and other suction troubles? Author reviews basic theory of cavitation; gives a way to select the right pump and interpret its performance.

Introducing the Space Crank * 50... J O Predale and A B Hulse Jr
Here's a 3-D mechanism that can replace various linkages and cams in automatic machines. Article shows design variations of the crank, gives explanatory equations and curves.

Design Features in New Products 54... Fast industrial camera feeds film from hopper, allowing speed of 1600 frames/sec to be reached in 3 milliseconds; this crawler crane disassembles itself, loads the parts and is ready for travel; trucks has rubber knees to help it over the bumps.

These Parts Carry Their Own Adhesive 57... R C Lillie, Angier Adhesives
No muss, no fuss when such components go into assemblies. Just peel off the backing sheet—and hand pressure is enough to give a quick and reliable bond.

SPECIAL REPORT

Electromachining Speeds Its Attack 59... H L Kee, Assistant Editor
Though it machines the "unmachineable," the method has had limited application because of its slow pace. Now, faster metal removal widens its field. Here's latest data on a new Japanese machine that leads the trend to higher cutting speeds.

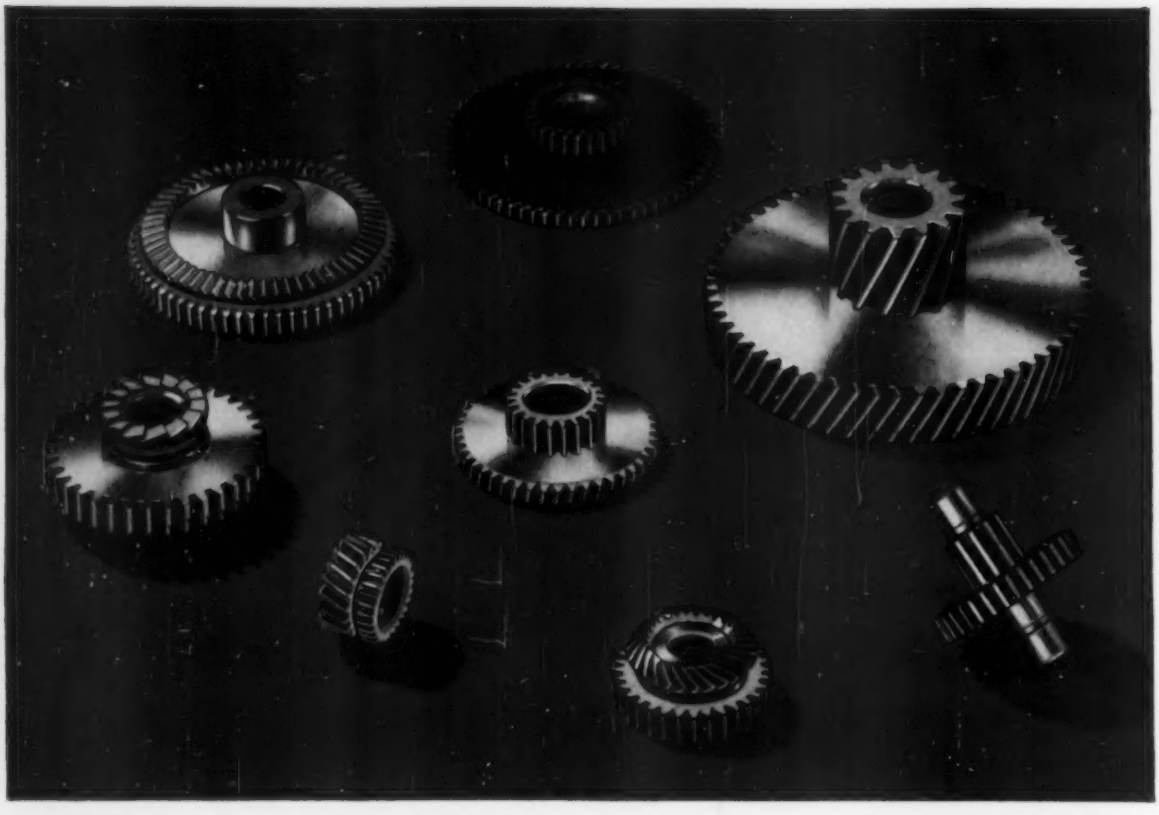
DESIGN FILE

Rotary—Linear Motion: 20 Converting Mechanisms 64... Federico Strasser, Mankowitz & Strasser Ltd
Basic arrangements and adjustable crank-throws, plus some special cases for dwell periods and intermittent motion.

The 6 Types of Corrosion: a Preventive Guide 67... P C Noy, Canadian General Electric Co
The author describes each of the basic causes of trouble, along with examples and preventives.

DEPARTMENTS

Interesting to Note	5	Editorial	41
Developments to Watch	19	Significant Components	71
The Engineering Week	21	Catalogs and Bulletins	83
Coming Events	25	Design Abstracts	89
Reader to Editor	26	New Books	91
Design Perspectives	39	* Current Reprints	94



Do Your Gear Applications Require CLUSTERS?

FRACTIONAL HORSEPOWER GEARING

GEAR
Specialties, Inc.
2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

If you are producing Aerial Cameras—Windshield Wipers—Tape Dispensers—Fire Control Apparatus—Computing Equipment—or many other items where combinations of different Gear types are needed, G.S. Clusters will give you the maximum in precision design. Spurs or Helicals in combination with straight and spiral bevels, spur pinions, worm gears, and clutches are all made with the consistent "better-than-spec" quality for which G.S. is famous all over the country.

Perhaps you have an irksome problem involving such clusters—or some other Small Gearing application. G.S. engineers will be glad to sit down with you and discuss solutions, in the light of our more than four decades of experience in every area of U.S. industry where precision Small Gearing is used in quantity. Why don't you write or phone us—today?

SEND FOR G.S. ***illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!***

43 Years of Specializing in Small Gearing!

ALBERT HAUPTLI *publisher*

ELMER J TANGERMAN *editor*

ROBERT W CARSON *managing editor*
ROBERT E ABBOTT *senior associate editor*
RICHARD M KOFF *senior associate editor*

PAUL N ANDERSON *associate editor*
JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD R PARK *associate editor*
ROBERT S PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
DOUGLAS C GREENWOOD *assistant editor*
PHYLLIS B SWEED *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*

JACK MEYER *Los Angeles*
SETH PAYNE *Washington*

RICHARD E ROOMAN *art director*
E G LOADER *assistant art director*
ANGELA M GIACIN *assistant*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant*

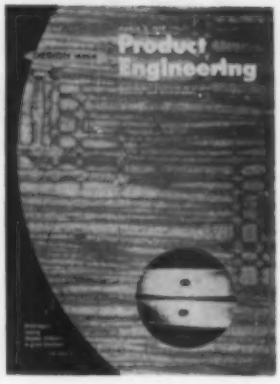
JOSEPH KERR *consulting editor*
ROBERT E BRUCKNER *consulting editor*

DEXTER KEEZER *director, economics dept*
GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
WILLIAM G MELDRUM *Cleveland*
STEWART W RAMSEY *Chicago*
MARGARET RALSTON *San Francisco*
JOHN KEARNEY *Los Angeles*
MICHAEL J MURPHY *Los Angeles*
RAY BLOOMBERG *Seattle*
CHARLES T DIXON, JR *Atlanta*
KEMP ANDERSON, JR *Dallas*
JOHN WILHELM *editor, world news*
JOHN TUNSTALL *London*
JOHN SHINN *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
ROBERT GIBSON *Moscow*
ONNIC M MARASHIAN *Beirut*
PETER WEAVER *Mexico City*
JOHN PEARSON *Caracas*
SILKE BRUECKLER *Bonn*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

STANLEY J ALLING *associate publisher*
PHILIP G WEATHERBY *advertising sales manager*
P F PRITCHARD *manager, market research*
ROBERT C MATTOON *circulation manager*
C C KANE *reader service manager*
RUSSELL T DOUGLAS *business manager*

Interesting to Note . . .

Portrait of Strain



Our cover this week pictures a major development in the field of stress analysis. The small inset shows a piece of cold-rolled mild steel that had been previously subjected to high torque loading. Resulting yield is shown by the fringe patterns (enlarged microphotograph) in the PhotoStress plastic bonded to the surface of the specimen.

In effect, the plastic acts like an unlimited number of tiny strain gages. With a reading system employing light-polarizers and a microscope, it is possible to observe and photograph color fringe patterns, proportional to strain, in the grain of the metal surface. More information on this is in the news story on page 21.

In 1863 occurred one of the basic discoveries in stress analysis. A Scotsman, Sir David Brewster, used polarized light to detect various colors within a piece of glass under tension. Oddly enough, this important concept lay dormant until 1920 when suddenly three different scientists in three different countries simultaneously picked up the basic concept of photoelasticity where Brewster had left off. Prof. Baes, a Belgian, tried applying this experimental method to solve stress problems in bridge construction. Prof. Coocker, in England, as well as the Frenchman, Prof. Mesnager, were doing likewise. The method: make glass models and, under polarized light, subject them to stress. With the bi-refringent (double refracting) properties of glass, points of weakness could be observed, but it was difficult and sometimes impossible to correlate the strain in glass models with that in iron and steel.

Then, in 1930, Mesnager suggested coating metal parts with the double-refracting glass. It was a good idea—but the glass broke. Even bi-refringent plastics were tried, but he could not find a method of properly coating plastic to metal and making accurate measurements. Between 1930 and 1950 the use of models of solid plastic proved fine for studying strain in design—but it was still impossible to correlate stress in plastic models with stress in actual metal parts subjected to live loads.

The major breakthrough occurred in 1952. While working on his doctorate the Frenchman, Felix Zandman, had been using photoelasticity to measure the stress of a plastic model of a turbine component. But when his figures were compared with the stress of the steel component itself, they didn't check. So, for two years, Dr. Zandman hunted a way to successfully bond a bi-refringent

(CONTINUED ON PAGE 7)

Product Engineering
A McGRAW-HILL PUBLICATION

March 2, 1959 Vol. 30, No. 9

PRODUCT ENGINEERING is published weekly, with an additional Design Digest issue in mid-September, by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, N. Y. See panel right for directions regarding subscription or change of address.

EXECUTIVE, EDITORIAL, CIRCULATION and ADVERTISING OFFICES: 330 W. 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice-President; L. Keith Goodrich, Vice-President and Treasurer; John J. Cooke, Secretary. Officers of the Publications Division: Nelson L. Bond, President; Harry L. Waddell, Senior Vice-President; Ralph B. Smith, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice-President and Circulation Coordinator.

Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders. Send to address shown in box at right.

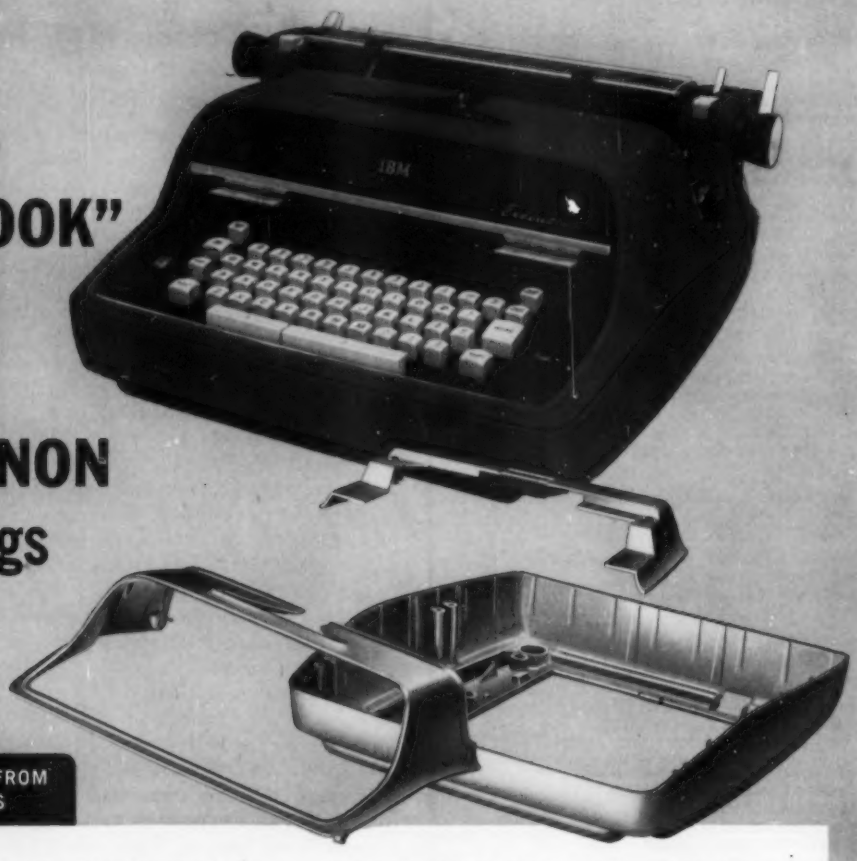
United States subscription rate for individuals in the field of the publication, $5.00 per year, single copies fifty cents; Canadian subscription $7 per year; foreign $25 per year, payable in advance. Second-class postage paid at Albany, N. Y. U.S.A. © Copyrighted, 1959, McGraw-Hill Publishing Company, Inc., all rights reserved.

PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the Editor.

SUBSCRIPTION. Send subscription correspondence and change of address to Fulfilment Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, N. Y. Subscribers should notify Fulfilment Manager promptly of any change of address, giving old as well as new address, and including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective.

Postmaster: Please send form 3579 to PRODUCT ENGINEERING, 330 W. 42nd St., New York 36.

IBM's "NEW LOOK" enhanced with MT. VERNON Die Castings



CASE HISTORIES FROM MT. VERNON FILES

Behind the sleek silhouette of the dramatically new IBM electric typewriters is "more than a quarter of a century of experience . . . a combination of styling and engineering advances" that promise — and deliver — better performance and easier typing.

For its enclosure IBM knew what it wanted: a new high in eye-pleasing design combined with the many low cost, production benefits of die-casting. It was only natural that, for these die castings, once again, they turned to Mt. Vernon, a reliable supplier to IBM for over 25 years.

And, once again, they found Mt. Vernon's coordinated four-fold service — designing, die making, casting, and machining—equal to the job of meeting their strict requirements: strong, gracefully arched, thin-walled, large aluminum sections that match and fit perfectly. The three castings that cradle and enclose the intricate typewriter mechanism are delivered completely machined, ready for finishing.

Like IBM, leading manufacturers in all industries know and rely on Mt. Vernon's experienced use of its complete facilities for die cast zinc and aluminum parts ready for assembly. These services, all under one roof in 200,000 square feet of space, may hold the answer to your design and production problems. Think about it . . . and let us know. We'll gladly talk it over, without obligation. Just call your nearest Mt. Vernon sales representative.

MT. VERNON DIE CASTING CORP.
STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

SALES REPRESENTATIVES

BIRMINGHAM, ALA.: Mr. I. B. Armstrong, Jr., P. O. Box 2244
BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
LUTHERVILLE, MD.: Mr. C. McIntosh Gordon, Box 55, R.R. No. 1
PITTSBURGH, PA.: Mr. Andrew W. Anderson, 300 Pasadena Drive So.
QUINCY, MASS.: Mr. Edmund W. Libby, 91 Merrymount Rd.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

plastic directly to metal in order to accurately measure stress. When he hit on the solution seven years ago, Zandman announced his development in Brussels before a group of theoretical scientists. By coincidence, a physics professor from Brown University, Dr. D. C. Drucher, soon presented a paper stating it might be possible to measure stress in metal parts. In a way, Zandman had shown how to do it a few hours before.

It did not receive wide recognition until 1956 when the Zandman concept, PhotoStress, was presented in PRODUCT ENGINEERING's pages and in Pittsburgh before the Society of Experimental Stress Analysis. Frank Tatnall, vice-president of Tatnall Measuring Systems (a subsidiary of The Budd Co) and a pioneer in physical-testing methods, became interested. In Jan 1957, he retained Zandman to carry on research and development of PhotoStress, and Zandman's latest concepts are presented here in the article on p 43.

No Tanks

Military equipment has often been converted into consumer products—radar, sonar, a British jeep pictured on p 55, jets, etc. Rarely does a consumer item find its way to military service. The tank is the exception; it started as a farm implement, became a military weapon and recently has been adopted as a tool for professional house wreckers.

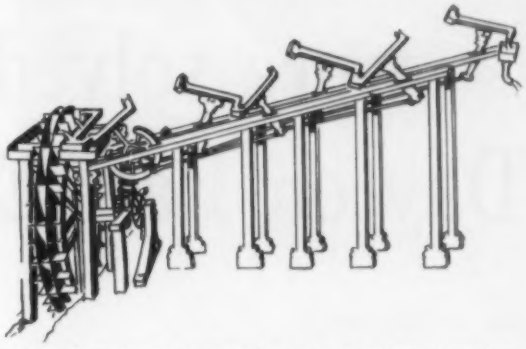
As soon as the crawler tractor proved successful on the farm, it was only a matter of time before Army men became interested. Strangely enough, the first military contingent to see the tractor turned it down. In 1912, Leo Steiner, a Hungarian dealer for American tractors, so impressed top brass of the Austro-Hungarian war department that they wanted to manufacture a tractor-type military vehicle in Austria. But when the German War Department saw the plans it overruled Austria, telling Steiner, "We are not interested in this engine. It is of no importance for military purposes."

In 1914 the British became interested in an armed "land destroyer with a track-type base." The First Lord of the Admiralty, Winston Churchill, recommended building "special mechanical devices" for crossing trenches and within a year the military version of America's tractor was being mass-produced. Called "the Yankee machines that climb like hell," the strange contraptions were secretly assembled and shipped to the Western Front. When questions were asked at the docks during loading, counter-intelligence passed word that they were a new type of water tank for the British troops in Egypt. The name "tank" stuck.

Turriano from Toledo

Ancient Roman aqueducts have, for generations, been models for young engineers. Questions on how to convey water, always a problem, have been solved by strange devices, many based on these first Roman aqueducts.

One weird device was conceived by a clockmaker, Juanelo Turriano in Toledo, Spain a few years after Columbus discovered America. The problem was to convey water from the Tagus River to the Alcazar Palace situated on a hill 300 feet above the river. Turriano's device consisted of an undershot wheel over the river, turning several gears which in turn operated a rocker arm apparatus. Water would be lifted to a scoop in one



rocker, then dumped into the scoop in the rocker above it. The amount of water lost en route is not known, but it is recorded that after several years the people of Toledo went back to hauling their water by donkey.

A device of this nature could not be called a true pump although it attempted to duplicate a pump's function. Even with modern pumps the problems of supply are still with us. On page 47 the article discussing pump cavitation brings to light problems with liquid pumps which never bothered Turriano from Toledo.

Made in Japan

For years the tag, "Made in Japan," may have inferred that the product was a copy. Not so any more. Japanese designers are now giving their products an instinctive "Japanese look" (*PE—Jan 12, p 38*). In some fields they are now assuming leadership in design. The electrical discharge machine discussed on p 59 is one of the best on the market, and it contains a "Made in Japan" label.

First American announcement of this process was the "tap disintegrator," developed late in World War II at Curtiss-Wright for removing broken taps from aluminum aircraft-engine elements. This was widely exploited shortly after the war in the US, but in 1947 *American Machinist* published a translation of a Russian paper announcing discovery of the surface-machining principle —applying, in effect, the tap-disintegrator idea to surfaces and shapes. Little notice was taken of it at the time in this country, the assumption being made that it was Soviet propaganda, and another case of re-invention. However, by 1951, US Government reports showed 5000 machines operating in the USSR. Dr. Inoue, who worked out Nippon's machine, frankly credits the USSR as his source for the principle, and says it was independently invented there by two engineers Lazarenko (who are husband and wife) in 1946. The latest report is that the USSR has some 30,000 machines in operation, and some recent startling developments have been made, first reported last year (*PE—July 14 '58, p 15*) by E. J. Tangerman, who by coincidence was involved with the first reports on tap disintegration and Russian surfacing with this principle. **—Benedict A Leerburger Jr**

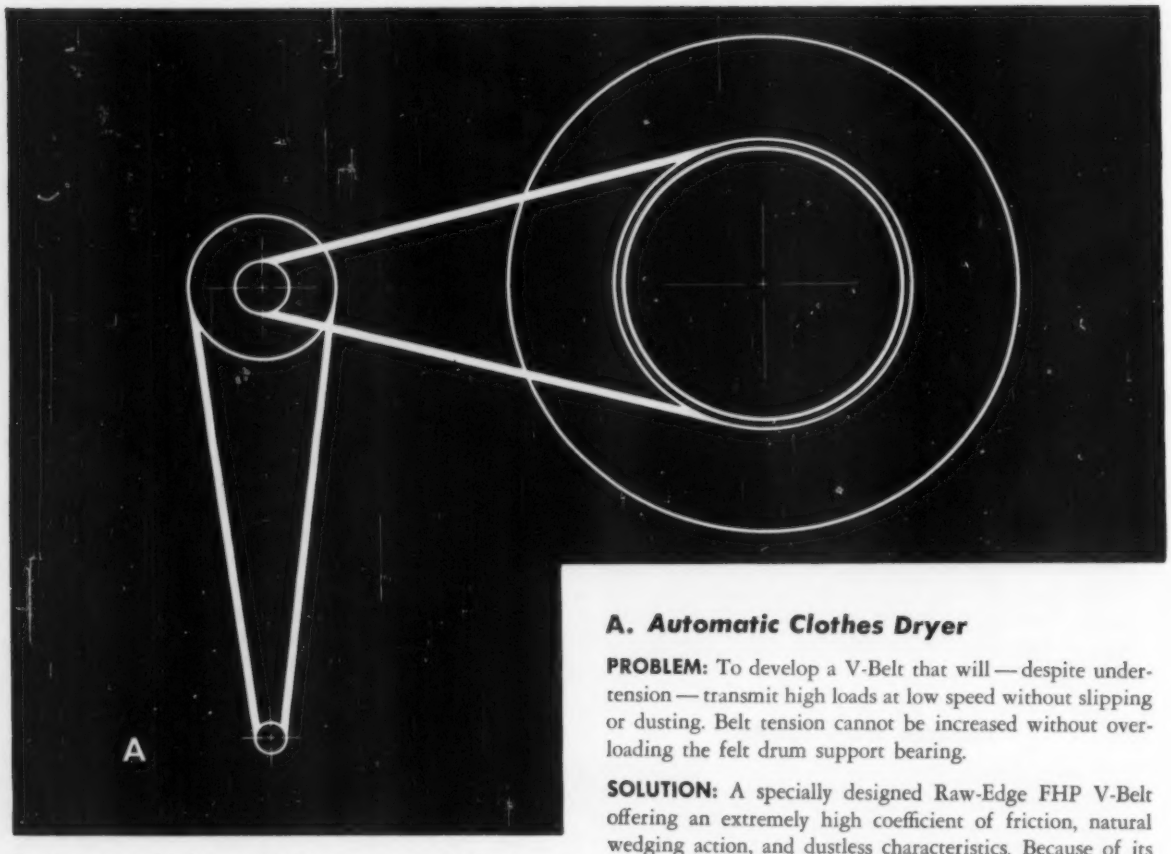
How 3 dissimilar drive problems were solved with special Dayton Raw-Edge FHP V-Belts

THE PROBLEMS:

A. *To transmit high loads using sub-diameter pulleys*

B. *To transmit high loads at variable speeds without vibration*

C. *To transmit high loads with minimum V-Belt tension*

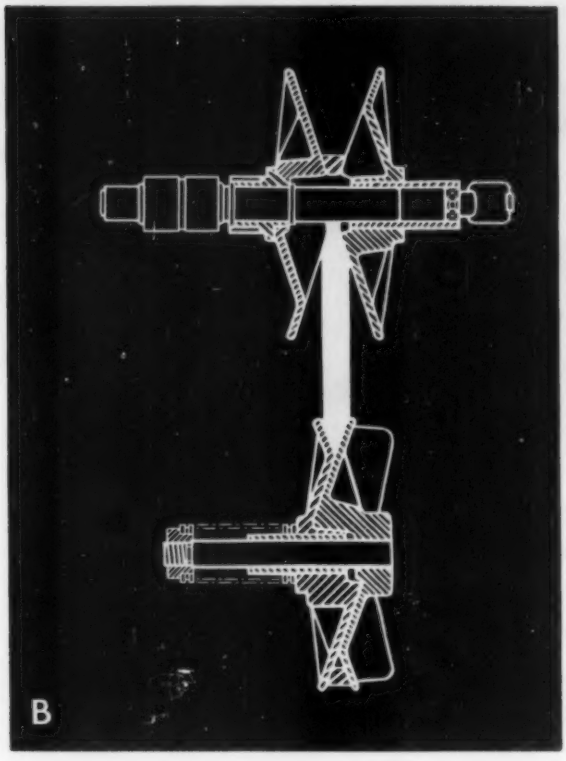


A. *A noteworthy feature of this automatic clothes dryer is the use of a rolled flange on the dryer drum as the final pulley in a 35:1 two-stage reduction drive. The dryer drum is supported by felt bearings.*

A. *Automatic Clothes Dryer*

PROBLEM: To develop a V-Belt that will — despite under-tension — transmit high loads at low speed without slipping or dusting. Belt tension cannot be increased without overloading the felt drum support bearing.

SOLUTION: A specially designed Raw-Edge FHP V-Belt offering an extremely high coefficient of friction, natural wedging action, and dustless characteristics. Because of its high traction ability, the raw-edge belt will pull the load required without the high tension which would collapse the felt bearing. The inherently dustless characteristic of Raw-Edge V-Belts allows clean operation.



B. *Interdigitary pulleys are employed by a popular home workshop tool to provide an extraordinarily wide range of variable speeds within a limited drive space. By this unique method, the pitch diameter of each pulley can be varied from 1-1/2" to 5-3/16".*

B. *Multi-Purpose Home Workshop Tool*

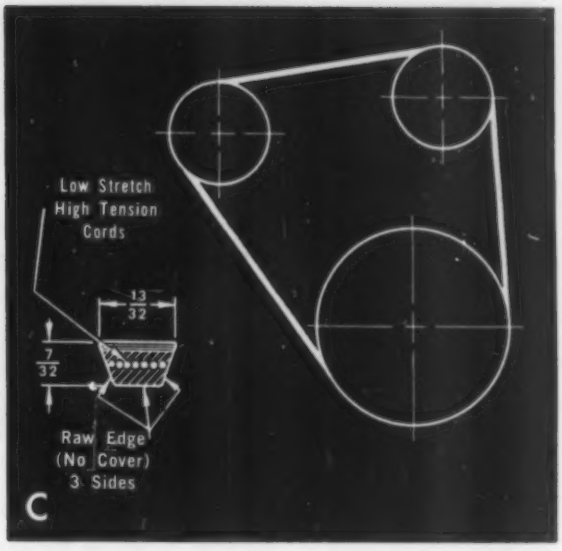
PROBLEM: To transmit heavy loads with interdigitating variable speed pulleys without vibration. The required V-Belt must not take a set due to long periods of idleness and — for safety — must slip under overload.

SOLUTION: A special Raw-Edge Die-Cut V-Belt compounded from special rubbers and fabrics which can be used only in Raw-Edge construction. A full plyed-up section, manufactured under especially close width and length controls, was the solution to this problem. The belt in use

— has the required coefficient of friction to transmit heavy loads and slip under overload

— won't take a set even when stored under tension for long periods

— has the ability to flex over small diameter pulleys



C. *Because of the extreme compactness of a space saving design, this automatic clothes washer employs small diameter pulleys.*

— resists twisting when operating over the interrupted surface of the interdigitary pulleys and thus avoids setting up vibration.

C. *Automatic Clothes Washer*

PROBLEM: Small diameter pulleys with a limited arc of contact caused belt slippage and premature failure in a drive operating at high speed and under heavy loads. Tension adjustment was limited and somewhat inaccessible.

SOLUTION: Employment of a special Raw-Edge Molded FHP V-Belt, with its high coefficient of friction and inherent wedging action, to attain high tractive effort despite the limited arc of contact. As a further refinement, the belt being furnished by Dayton is built with special "low stretch" cords in the strength section to minimize the need for tension adjustment. This solution made redesigning around larger pulleys and heavier belts unnecessary.

Dayton's V-Belt Engineering Service

For help on your drive designs, Dayton Engineers are at your service with the correct V-Belt to fit all your requirements.

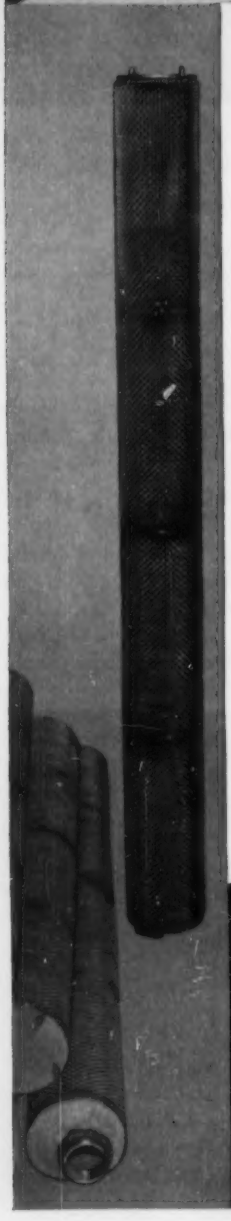
To contact one of these V-Belt Design Specialists or for more information on special Raw-Edge FHP V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.



Who cares about your Wire Cloth Fabrications?

CAMBRIDGE does . . .

that's why you automatically get service with your order . . . whether you need dozens of midget strainers or a single giant-sized retaining screen.

Careful, competent workmanship and constant inspection assure you of quality . . . modern machinery and accurate scheduling assure you of prompt delivery. And, a Cambridge Field Engineer follows up your order to make sure our product is giving you the best possible service. Let us quote on your next order for wire cloth fabrications. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. We'll work from your prints or draw up prints for your approval. Call your Cambridge Field Engineer . . . he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

The Cambridge Wire Cloth Co.

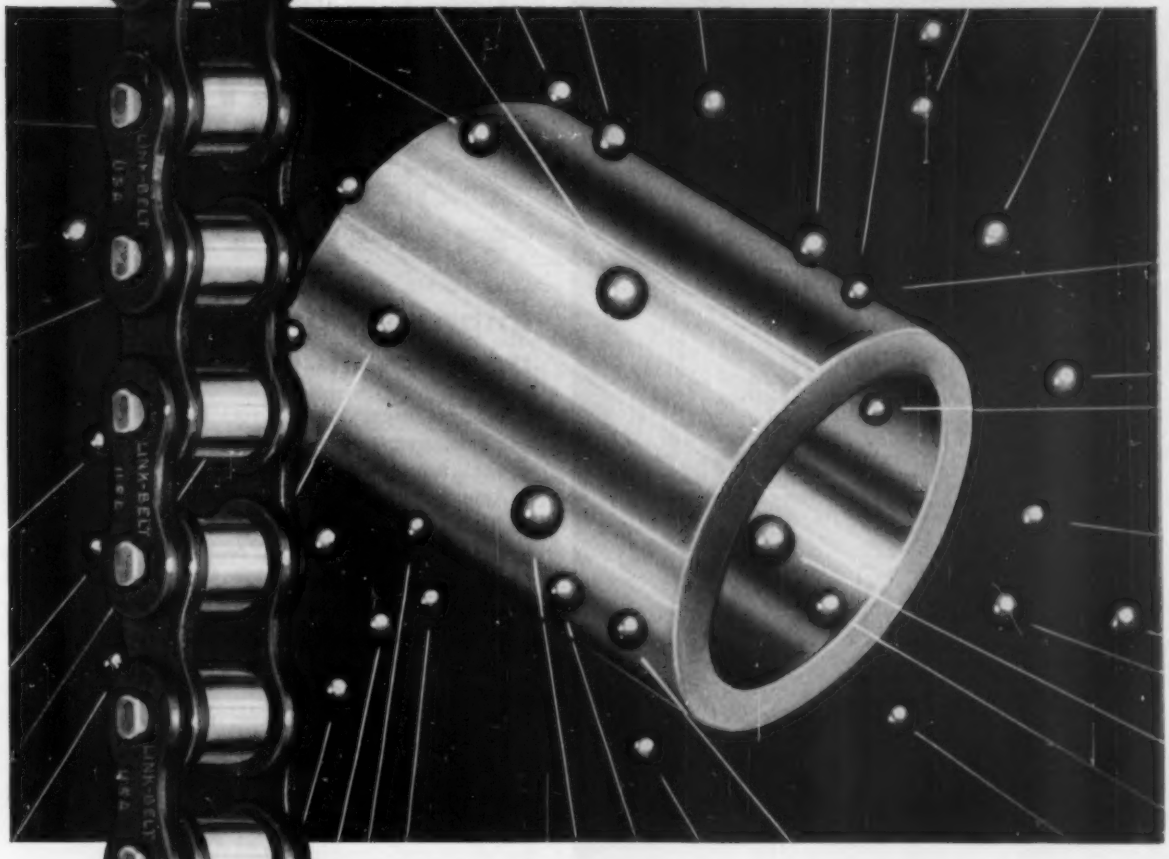
Department P • Cambridge 31, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

Shining example of "extra" chain quality

SILVER-BRITE

SHOT-PEENED ROLLERS



EXTRA LIFE IS POUNDED IN AND NOT POLISHED OUT

Rollers for Link-Belt precision steel roller chain are now finished by a special burnishing process to a "Silver-Brite" luster! And this is accomplished *without grinding away the benefits imparted by shot-peening*—a Link-Belt process that cold works the metal and provides extra fatigue life.

Many more special Link-Belt "extras" contribute to the dynamic strength so important for today's heavy loads and high speeds: close heat-treat control . . . lock-type bushings . . . pitch hole preparation . . . pre-stressing.

Ask your Link-Belt office or authorized stock-carrying distributor for new 154-page Catalog 2657—the most complete roller chain data book ever compiled.

LINK-BELT

ROLLER CHAINS & SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,978

CIRCLE 106 READER SERVICE CARD

CIRCLE 107 READER SERVICE CARD →

HOW PORCELAIN ENAMEL'S CORROSION RESISTANCE improves product performance

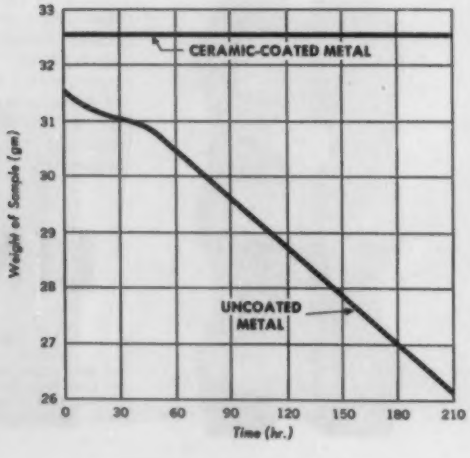
Hard and impervious, Porcelain Enamel is an inorganic, vitreous, siliceous coating permanently fused at high temperatures to metal.

Acid-resisting grades are immune to most acids, including sulfuric and nitric. Under the Porcelain Enamel Institute's acid resistance classification, Class AA acid-resisting Porcelain Enamel coating .004" thick should withstand a boiling 5% sulfuric acid solution during many months of continuous attack.

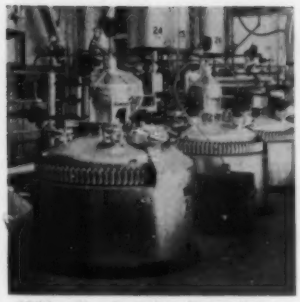
Various types of ground coats, one-fire enamels and cover coats may be selected to suit the application and use conditions.

All grades of Porcelain Enamel are resistant to organic solvents and alkaline solutions. Certain grades are unaffected by soil corrosion where acid, moisture and organic materials are encountered.

1. Pipe and Fittings
2. Processing and Storage Tank
3. Bearing for Pumps Handling Corrosive Liquids
4. Jet Engine Liner
5. Strainer Basket
6. Industrial Water Heater



Curve showing the effect of prolonged heating at 1700° F for coated and uncoated type 321 stainless steel.



3000 gallon Porcelain Enameled reactors used for chemical processing.

Porcelain Enamel Combats *Chemical Attack*

In many chemical processing applications Porcelain Enamel has extended equipment life by as much as 500%—in all cases without danger of rust contamination of the product being processed. In smokestacks where combustion by-products have a corrosive effect on metal, the use of Porcelain Enamel has resulted in from three to five times longer service.

Porcelain Enamel, which has a hard, glass-like surface, resists corrosive attack from most chemicals, including those found in food, chemical, pulp, paper, dye and petroleum processing.

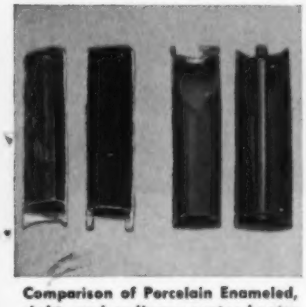
Porcelain Enamel Combats *High Heat Combined with Chemical Attack*

Ceramic-coated afterburners for jet engines.

High-temperature ceramic coatings, which are Porcelain Enamels fortified with refractory materials, resist corrosion at temperatures up to 2,000°F. Combustion chambers and exhaust systems of jet and rocket engines and heat exchangers of domestic and commercial furnaces are representative applications. Durability of stainless steels and high temperature alloys is extended substantially by means of a thin ceramic film which insulates the material from surface atmospheres.

In this type of application ceramic coatings do three things: (1) extend length of service of high-temperature alloys, (2) extend temperature service range of others, (3) permit substitution of low-alloy steels which are less rich in strategic elements.

Porcelain Enamel Combats *Moisture*



Comparison of Porcelain Enameled, right, and ordinary water heater after service.

Millions of water heaters are "glass lined" to handle severely aggressive waters under pressure. Porcelain Enamel also combats alkaline attack of sea water in marine engines where the hot exhaust mufflers and pipes constantly are exposed to cold sea water. Porcelain Enamel's excellent thermal shock resistance is an added bonus value.

Porcelain Enamel Combats *Atmospheric Corrosion*

In salt air and in industrial atmospheres where gases and smoke are factors, Porcelain Enamel has demonstrated extraordinary resistance to deterioration. Despite combined attacks of heat, cold, rain, snow, ice and sunlight many outdoor signs made of Porcelain Enamel more than 50 years ago still retain their gloss and original colors.

Architectural Porcelain Enamel resists the elements and corrosive atmospheres in seacoast and industrial areas.

Designers use **PORCELAIN ENAMEL** *for these additional properties*

Thermal Properties

Hardness

Electrical Properties

Color and Texture

PORCELAIN ENAMEL INSTITUTE
Associations Building
1145 Nineteenth Street, N.W.
Washington 6, D.C.

Please send the following:

- ☐ Porcelain Enamel Design Manual
- ☐ List of companies engaged in Industrial and General Porcelain Enameling
- ☐ Design information about possible application of Porcelain Enamel to _____ (type of product)

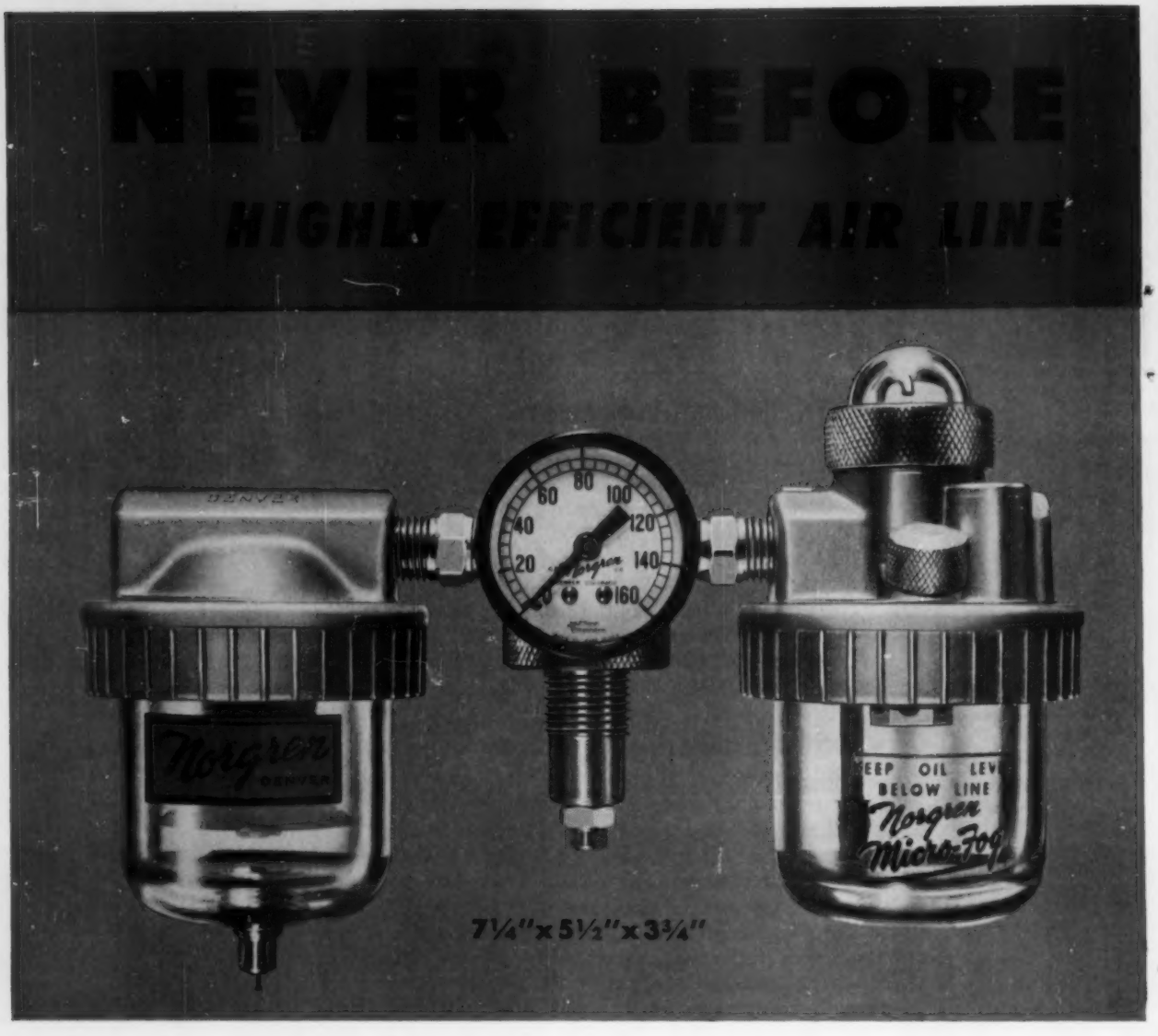
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

(Please Print)

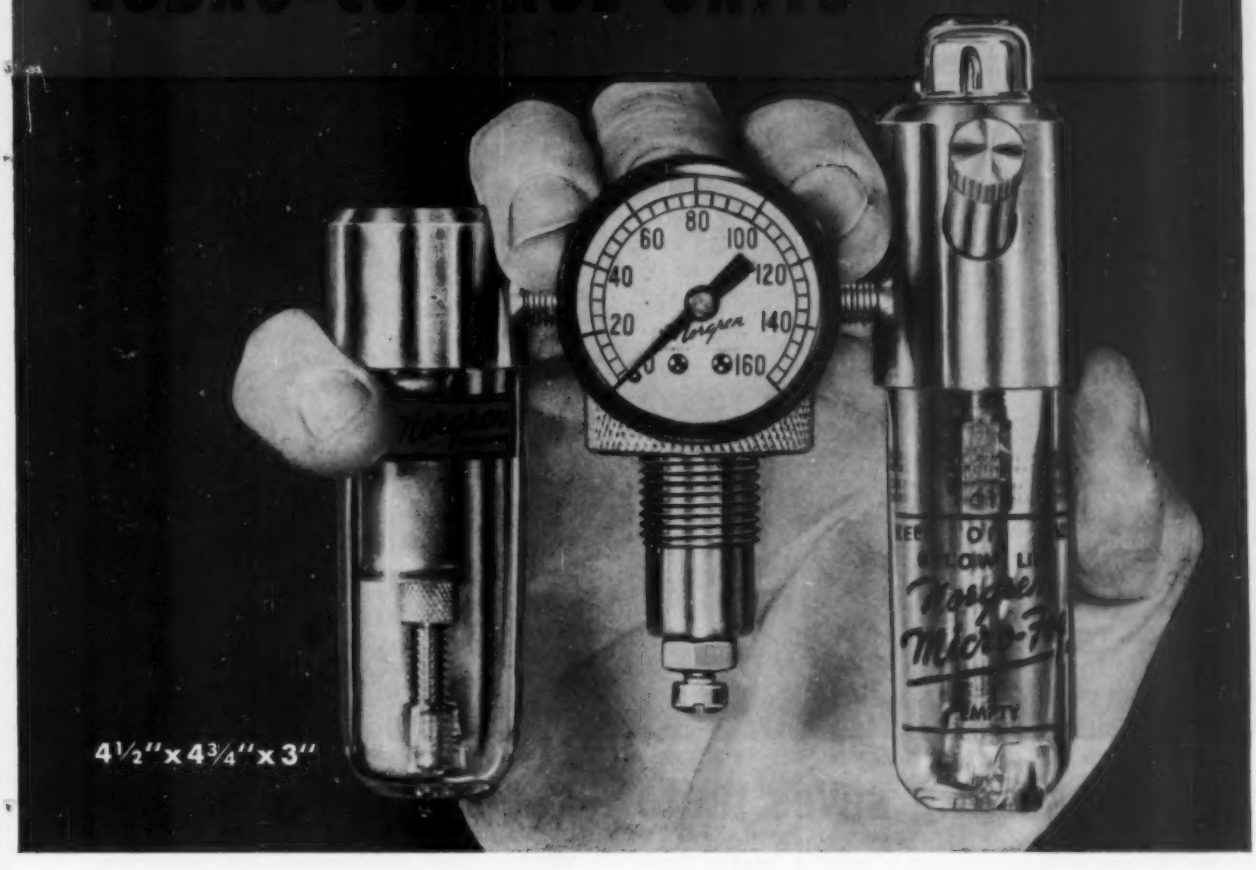


NEW SPACE SAVING *Norgren* MICRO-FOG Units

These new Norgren MICRO-FOG units: 1. Provide highly efficient compressed air processing for air tools and other air operated devices. 2. Provide efficient lubrication for bearings and machine tool components. Maximum operating pressure 150 psi, maximum temperature 120° F.

SO COMPACT...

LUBRO-CONTROL UNITS



Models Available for Air Flows from .05 to 20 cfm.

AIR LINE FILTERS

Two new air line filters provide efficient removal of liquids and solids from the air line, preventing damage to connected air equipment.

PRESSURE REGULATOR

A new small, compact pressure regulator is used for both series of Lubro-Control Units. It provides accurate, trouble-free regulation of the air pressure. Adjustable over a pressure range of 5 to 100 psi.

MICRO-FOG LUBRICATORS

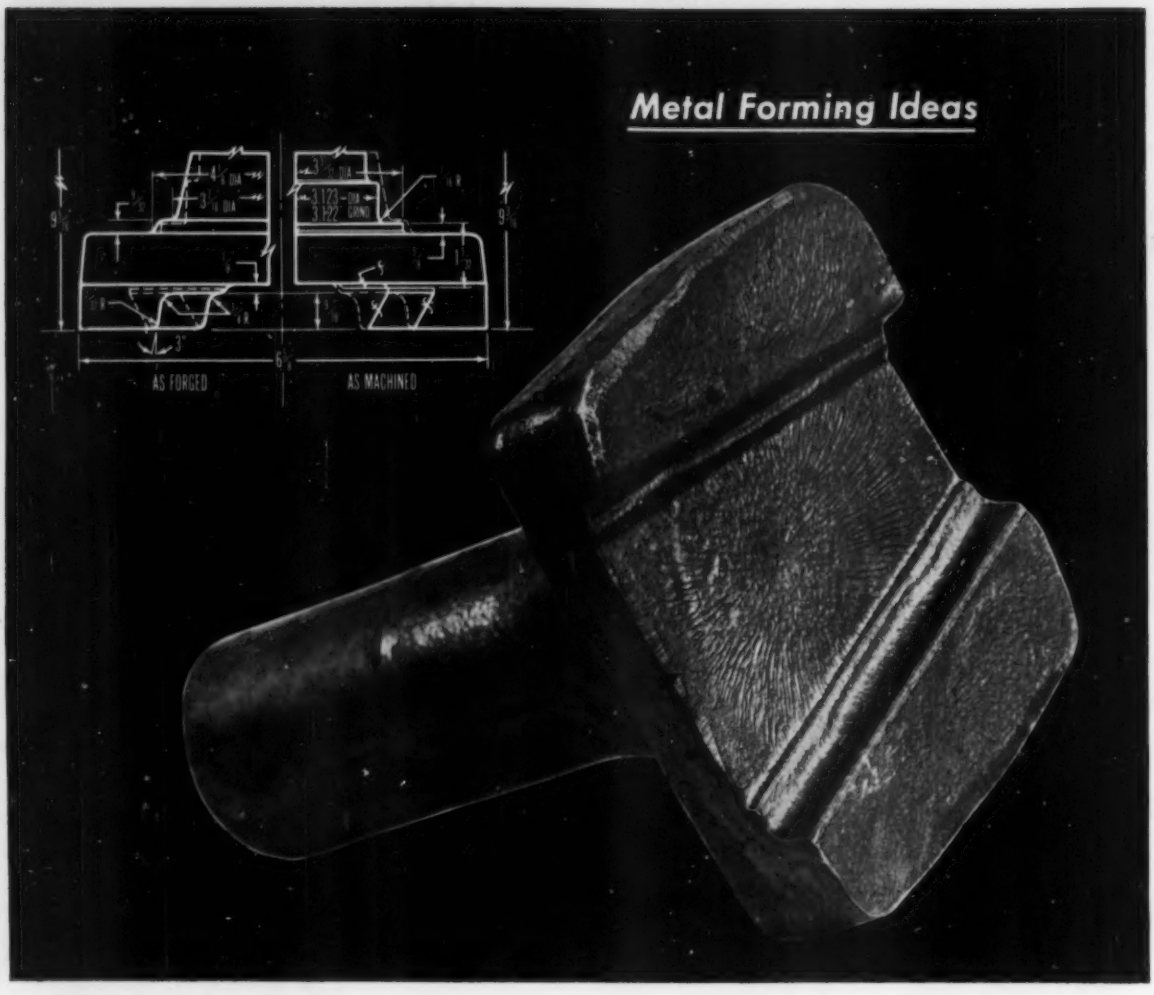
New MICRO-FOG Lubricators provide efficient and adjustable lubrication for bearings, air tools, air cylinders and other air operated devices.

If it's Norgren...It's Dependable.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FOR BROCHURE NO. 915B.

C. A. NORGREN CO.

3428 SOUTH ELATI STREET, ENGLEWOOD, COLORADO



How upsetting saves metal – reduces machining

Key part in a new multi-purpose farm tractor by Minneapolis-Moline was a steering link pedestal which involved unusual requirements both as to its final performance and actual production.

On the performance side, the design of forged pedestal gives Minneapolis-Moline customers a three-in-one tractor. In a matter of minutes change-over of three different front ends is made through the dovetailed groove.

From the production standpoint, the part was unusual in both shape and design—included a dovetailed groove in its head, plus an off-center shaft.

The requirement: A metal and a forming method which could produce this unusually shaped key component to meet all requisites on strength, lightweight, and yet afford maximum savings on both metal and machining of the forging.

The "Task-Forging" team at COMMERCIAL, working closely with Minneapolis-Moline engineers, proved that upset forging, despite the fact that it is rarely considered for the forming of off-center shaft components – particularly when they also involve a dovetail groove swaged in one end like this one –could best meet this requirement on every count. The steering link is now being successfully produced as an upset forging on a 6 in upsetter by COMMERCIAL.

As an upset forging it is more than strong enough to do the job. The controlled grain flow and efficient metal distribution afforded by upset forging assures maximum tensile and torsional strength. Equally important, there are no hidden, inside faults in the finished part–sound, dense, non-porous, forged metal from center-to-surface eliminates rejects, makes machining more effective.

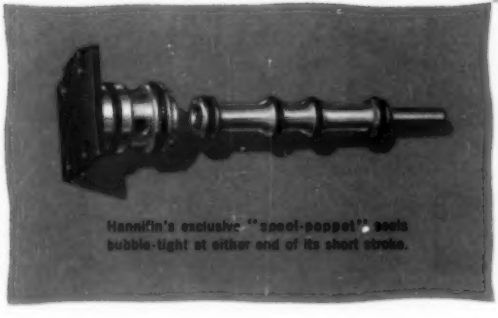
At a finished weight of 22½ lbs. (after machining) the steering link is easily light enough. And since the weight of the upset forging (before machining) was 27 lbs., the important savings in both metal and machining made possible by the inherent close tolerances of the upset forgings produced by COMMERCIAL are obvious.

Whether you're looking for help in the forming of a new component or only considering an improvement in the forming of an already existing part, "Task-Forging," COMMERCIAL's new metal forming service–backed by over 30 years of metal forming experience, plus specialized equipment which includes 1½" thru 8" upsetters – may be able to help you. Address inquiries to Commercial Shearing & Stamping Company, Dept. G-10, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

From HANNIFIN... unit construction to give you air valves that do more jobs

Hannifin ⅜" four-way valve with "universal" base and new Speed Control section. Single-solenoid actuated, 10 other actuators available.



Hannifin's exclusive "spool-poppet" seals bubble-tight at either end of its short stroke.

For complete J.I.C. compliance, valve is electrically inoperative until dust-tight, spiashproof solenoid cover is replaced and fastened tightly. Result: no more clogged, jammed solenoids.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

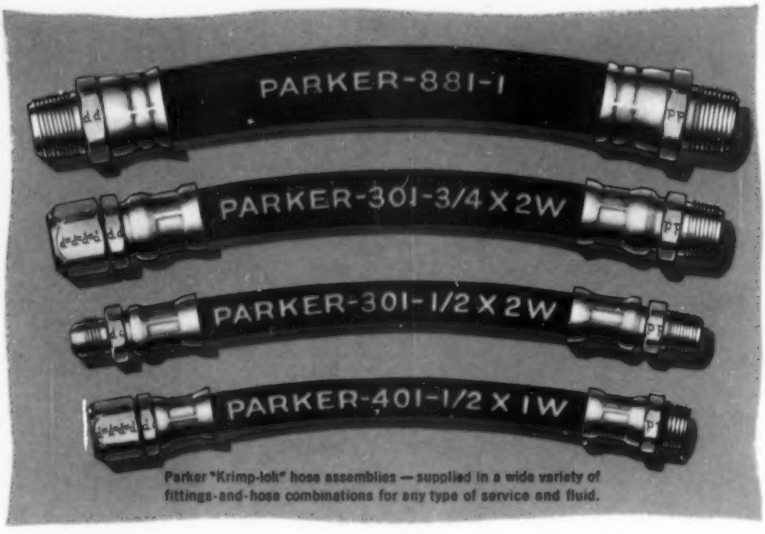
The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

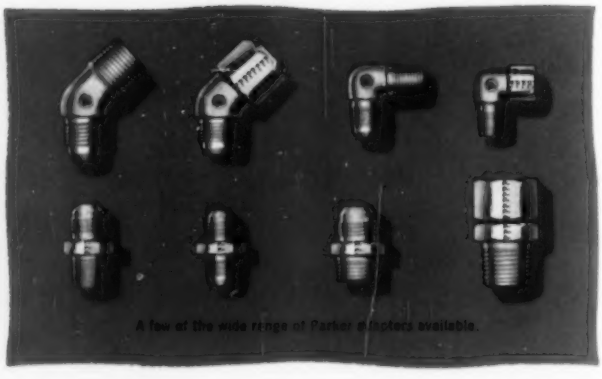
HANNIFIN COMPANY
525 South Wolf Road • Des Plaines, Illinois

Now from Parker

BOTH permanent-end and re-usable hose assemblies



Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.



A few of the wide range of Parker adapters available.

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

Parker

FITTINGS AND HOSE DIVISION

17325 Euclid Avenue

Cleveland 12, Ohio

Parker "Hoze-lok" no-skive hose fittings and Parker hose, the ideal combination for short-run production and quick, reliable field replacement.

DEVELOPMENTS TO WATCH...

For better brake linings . . .

. . . look to sintered-metallic materials, says N. H. McCuen of Chevrolet. Organic linings have several advantages—relatively low cost, only moderate variations with speed and temperature, and the like. But, he points out, they have been studied and used for so long, "they have possibly reached their peak of perfection with the materials to which they are now restricted."

Metallic linings, on the other hand, have been under intensive development for less than five years. There are still many combinations of metals, fillers, and modifiers that have not even been tested. New fabrication techniques may still be developed to bring down their relatively high cost.

Even though the organics can satisfy most of today's "ordinary" needs, the increasing demand for heat-resistant and moisture-resistant materials, plus their high performance at high speeds, makes it worthwhile to expend a considerable effort on the metallics to overcome such limitations as reduced effectiveness at low speeds and temperatures. It should also be possible to find a way to eliminate the need for extra machining to provide a smooth finish for the drum when metallics are used.

A "total-temperature measuring instrument . . .

. . . whose operating principle is calorimetry" has been developed at Cornell Aeronautical Lab to cope with the high-speed, high-temperature gases encountered in supersonic tests. The new instrument has a response time of less than one sec and has been designed to stand 9000 F at a heat flux density of 200 btu/ft/sec. Though it has not yet been tested at the top of its range, Cornell engineers expect it to overcome many of the limitations of presently available measuring systems.

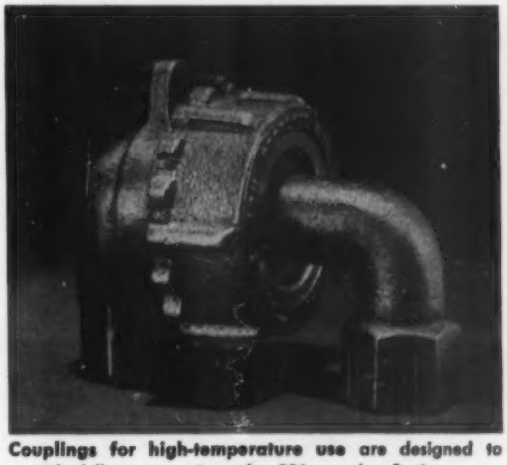
Cold-cathode radio tube . . .

. . . hailed as the "first major breakthrough in basic tube design in more than 30 years," is expected to approach the transistor in power economy and have great civilian as well as military potential. But its developers at Army Signal Corps Laboratories and Tung-Sol Electric now admit many technical and production problems remain to be solved before it's ready for general use.

This tube replaces the conventional hot cathode, from which electrons are "boiled off," with a tiny, magnesia-coated, nickel cylinder. A high-voltage (but low-current) field is provided to stimulate electron emission. According to Signal Corps, the tube can idle on as little as 5 millionths of a watt, requires no warmup time, and is potentially so reliable that it may outlast the equipment on which it is used. "It could also," says Signal Corps, "create a revolution in tube design by making possible the first reliable secondary emission multiplier—potentially the world's highest gain amplifier tube."

Swivel and ball couplings . . .

. . . for supply lines on platen presses, laundry machines, record presses, and other equipment that uses steam, oil, air or water, feature such packing materials as fluorocarbon plastics (PTFE), graphite-impregnated asbestos and graphite-impregnated compressed metal foil. JRH Products of Windsor, England, says the new fluorocarbon packings outlast the standard asbestos by factors as high as 300 to 1 (a full year in high-temperature service as against a day or two). The couplings themselves are expensive. Prices for the ½-in. size range from about $4 to $11 (US equivalent). But the special packing premium is relatively modest. For the single-ball coupling pictured, the fluorocarbon type is being priced only about 15% higher than standard units; the swivel type is about 20% higher.



Couplings for high-temperature use are designed to provide full rotary action, plus 30° angular flexing.

←Circle 110 for Fittings, 111 for Valves

DEVELOPMENTS TO WATCH...

Thermitic cermets made with beryllium . . .

. . . seem to offer a promising route to fault-free, shock-resistant structural parts for high-temperature service, says Georgia Tech's Engineering Experiment Station. These are metal-ceramics formed by a thermite (heat-generating) reaction. First tests used mixtures of powdered aluminum and chromium oxide, producing chrome and alumina as a result. Recent tests, though, indicate beryllium is a superior reducing agent and that the resulting cermet, containing beryllia, is not only lighter in weight but also has a higher melting point and greater resistance to thermal shock. (For another new Tech development in the high-temperature field, see *PE—Feb 23*, p 14.)

Newest structural material . . .

. . . for use where conditions of heat and irradiation pose severe design problems, is an old friend, silicon carbide. The material is showing promise as a semiconductor too—in high-temperature transistors, and electroluminescent and photoconductive devices (*PE—Feb 24 '58, p 8 and Sep 15 '58, p 74*).

Possibilities for this versatile material in thermoelectric generators are also being explored, and will be reported at several meetings during the coming year. It's already on the agenda of an Air Force-sponsored conference scheduled for next April at the Cambridge Research Center.

Interest in silicon carbide for nuclear use stems from resistance to heat and corrosion, and its having a relatively low neutron cross-section (capture rate). Here, though, much research remains to be done. As J. H. Crawford and M. C. Wittels of Oak Ridge point out, silicon carbide, like graphite, seems to store energy and expand under neutron bombardment. It may also lose some of its hardness. On the other hand, Aerojet-General nuclear engineers rate SiC as one of the most promising materials of construction for nuclear rocket test-stands, and envision its use particularly in flame deflectors.—ARG

Industrial power units in the 18- to 85-bhp range . . .

. . . recently developed in England are soon to be made available here. These are 4-cyl gas and diesel engines with pushrod-operated overhead valves and 3-bearing crankshafts, designed for electrical starting and V-belt drive. Cooling is thermostatically controlled, with pump circulation and fan assistance. Most of the engines have wet liners fitted to all cylinders, and most have mechanically driven fuel-lift pumps. Expected applications include fork trucks, dump trucks, cultivators, concrete mixers, welders, pumps and mobile cranes.

Standard Motor Co Ltd, Canley, Coventry, Warwickshire, is the manufacturer; Standard-Triumph Motor Co, New York, the American representative.

New route to vibration damping . . .

. . . is an unusual cushioning material, developed by the Air Force for delicate electronic parts. It consists of a multilayer grid of Teflon (TFE fluorocarbon plastic) ⅛-in.-dia rods embedded in a matrix of silicone rubber.

The material will stand temperatures from −85 F to 482 F, and shows a maximum transmissibility at 0.1-in. input double amplitude of 2.1—much less, says Wright Air Development Center, than the rubberlike materials presently used by the aircraft industry for protection of critical equipment.

A report on this material, and more than half a hundred others, is now obtainable from OTS, Dept of Commerce, Washington, DC (153 pp; $2.75).

Frequency-control apparatus . . .

. . . that will "completely stabilize generation of electrical power" and can be applied to "everything from jet aircraft to utility power plants," has been designed and patented by Siegler Corp and is now in the prototype stage.

Engineers at Siegler's Hallamore Div describe it as an electronically controlled device for generating alternating current, with absolute stable frequency. Instead of controlling the frequency by controlling the speed of rotation of the alternator, the new device controls the rotation of the alternator's magnetic field by means of a comparator or demodulator. Basic components of the system are relatively standard and simple in construction, and many different combinations and arrangements of components are possible. —ARG

Pick off Stress Data from Photomicrograph

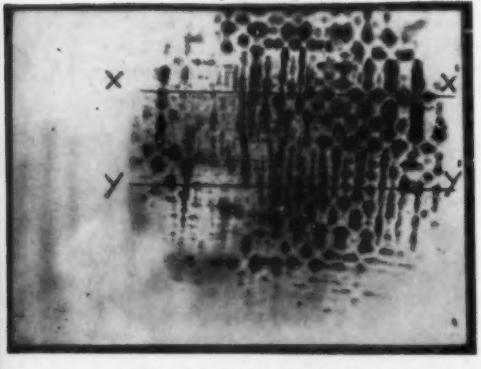
PHOENIXVILLE, PENNA—A new method of measuring strain on a microscopic level has been developed by Dr Felix Zandman of Tatnall Measuring Systems Co, a subsidiary of the Budd Co. This is an extension of the PhotoStress method desscribed on Page 43 that uses a bi-refringent plastic cemented to the part to disclose surface strains through color fringes.

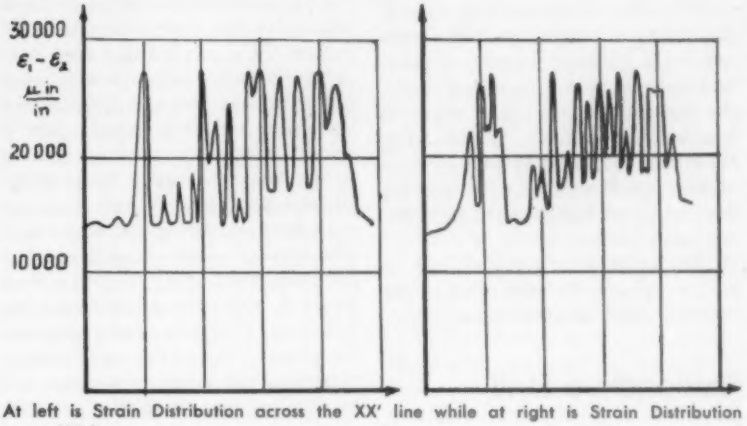
First used for examination of strain distribution on full-size surfaces (inset on cover) the method can now be applied to show strain around individual crystals, as shown in the magnified field on the cover. This magnified fringe pattern shows plastic yield under torsional stress applied to a piece of cold-rolled mild-steel strip. Internal stresses set up in rolling vary from grain to grain; application of uniform external torsional stress thus causes plastic yield in areas where internal and applied stress combine to exceed the elastic limit. These areas of yield show up as colored fringes, and clearly outline the crystal boundaries.

REFER TO COVER

The inset view shows the strain pattern actual size around a hole in the same part under a tensile load applied prior to the torsion loading. Fringe pattern around the hole is the familiar one for stress concentration under tensile stress. One interesting result of testing first in tension, then in torsion, was that torsional yield point was higher in areas that had initially yielded in tension—the result of strength increased from cold work induced by plastic flow.

Plastic deformation is shown below on a crystalline grain scale.





At left is Strain Distribution across the XX' line while at right is Strain Distribution across YY' line

Design Liquid Metal Package Heat Transfer Loop

CALLERY, PENNA—A package loop system that saves time preparing for study of liquid heat transfer has been designed by MSA Corp here. Adaptable to a variety of educational experiments and R & D investigations, the unit incorporates a heat-transfer test loop equipped with heaters, coolers, electromagnetic pump and flowmeters, heat exchangers, plugging indicator, cold trap and instrumentation. Its use bypasses time spent designing and assembling components for a high temperature heat-transfer loop. Filled with NaK, the over-all test loop and its auxiliaries simulate the actual liquid metal heat transfer system for nuclear reactors and chemical processes.

The system, installed at Washington State College in Pullman, Wash, under an AEC grant, is designed to operate at 1000 F and provides for flow and heat-transfer conditions for liquid metal to liquid metal, and liquid metal to air. Other applications include: (1) study of oxygen solubility in NaK, (2) investigation of the alloy's natural circulation characteristics, (3) study of pumps and flowmeter performance, (4) analysis of loop with reference to piping arrangement and layout, (5) study of pump and exchanger design, corrosion and mass transfer studies, valve and thermal insulation development, and metal stress investigation at medium and elevated temperatures.

Soviets Mass Produce Infrared Guided Missile

BONN—The Soviets reportedly are mass producing a simply designed surface-to-air missile that is destroyed in air if it fails to home on target. Such an erring missile is not tracked by ground control and guided home by complex systems.

An infrared guided weapon, this so-called Samovar, weighs 40 lb, including 31 lb solid fuel (believed to be yellow powder) and a 2.2-lb warhead. Missile's range is 2.8 mi. It is credited with speeds between 1250 and 1500 mph—fast enough to home onto supersonic aircraft flying at low altitudes.

The infrared homing includes a disk of zinc sulfite directly beneath the optical lens. Soviets claim the missile requires no doppler-discriminating semi-active homing apparatus, as is believed to be used with the US Hawk missile.

Each missile in a battery of unlimited size is mounted on an individ-

ual launching tripod coupled to a wire circuit. Through this arrangement, the homing systems of the weapons switch on simultaneously with appearance of low-flying aircraft on the radar screen.

When the fire button is pressed in the battery command post, the infrared heads home on target. As radiations increase with approaching target, the missile nearest the target is launched automatically. In launching, the missile automatically trips all other missiles in the battery to prevent their taking off until ordered to by the command post.

The warhead is provided with a hollow explosive to boost effect of the relatively small amount of explosive.

Radioactive Drill Locates Coal

PARIS—Radioactive isotopes have joined the French underground to locate coal. Engineers at research labs of Charbonnages de France (National Coal Authority) have developed a radioactive drill that indicates the presence of coal. The equipment consists essentially of a fragment of radioactive isotope mounted at the lower end of the drill and a Geiger counter shielded by a lead screen. More of the radiation emitted at the end of the drill is reflected by coal than by rock; coal is indicated by higher Geiger counter readings.

The equipment has already been used successfully in French mines, especially to locate veins interrupted by faults. The radioactive drill eliminates the need to take core samples, a difficult operation deep in a mine, during exploratory drilling to pick up an interrupted vein again.

Electronic Signal Straightens Curves

MILAN—An automatic electronic signal system for "blind" dangerous curves has been successfully tested on the Via Aurelia, Italian highway, between Celle Ligure and Varazze, near Savona, Italy.

The device consists of signal couples placed at the ends of the curve and set into operation by oncoming cars causing luminous discs to light respectively on the opposite side of the curve.

Beeps Relay Space Data

LOS ANGELES—One of the top-priority subjects scheduled for discussion when the Consultative Committee on International Radio meets here in April will be the regulation and control of communications from space vehicles. Better organization and international agreement will, it is hoped, make it possible to obtain a maximum amount of accurate information from future vehicles and prevent their transmissions from interfering with each other. The best—or worst—example of what the committee hopes to correct is Vanguard I which went into orbit in March of 1958 and whose solar-battery-powered transmitter may continue to transmit redundant temperature and pressure information for the next 200 years.

Telemetering equipment is the indispensable link with the scientists and engineers on the ground. The amount of data that can be transmitted, and the strength of the signal, are limited by the "growth rate" of the payload. Each pound that is launched may require more than 1000 lb in the first stage. And, since the weight-lifting ability of existing engines is fixed, a maximum limit is imposed on the payload. The number of measuring transducers has therefore been limited in US satellites by the weight of these devices and by the small number of channels available in the relatively simple transmitters. The basic concept of the US systems has been "keep the heavy equipment on the ground"; i.e., use relatively small transmitters to minimize weight and power requirements, and depend on enormous directional antennae connected to high-amplification receivers with automatic tuning to provide a maximum signal and minimum noise. The Explorer series of satellites, with telemetering equipment designed by Jet Propulsion Laboratories, contained two independent FM transmitters. The high-power transmitter (60 milliwatts @ 108.03 mc) was 50% amplitude modulated by four subcarrier channels to signal skin temperature, internal temperature, micrometeorite count and cosmic-ray count.

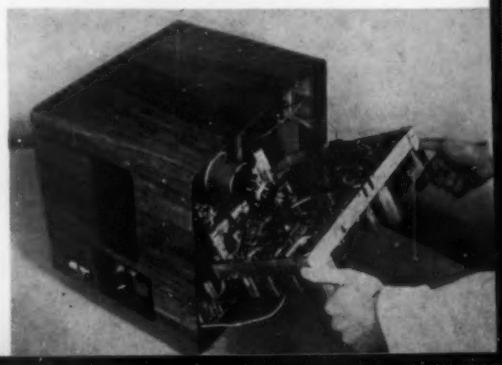
The low-power Microlock transmitter radiated 10 milliwatts at 108.00 mc; about half of this in the fundamental frequency on which the ground receiver was phase-locked and the rest in side bands which telemetered skin and nose temperature, and measured cosmic ray count and erosion.

The three US lunar probe programs included more channels than any of the others to telemeter radiation information, temperatures, micrometeorite impact and information on the earth's magnetic field. Again, the FM/PM system was used, except that there was only one phase-modulation channel on each of the 5 FM bands on the first two and 6 bands on the third. The Army's probe attempt had 3 FM/PM channels, one for radiation, one for temperature, and an optical indicator to tell if it passed the moon.

Future programs will probably stick to the FM/PM system, according to John Taber, a telemetering specialist at Space Technology Laboratories. The main reason for this is that there is already a big investment in ground receiving and tracking equipment; also that the hardware and experience that have resulted from years of using this system in missile and rocket research have minimized the possibility of malfunctions in the equipment or its operators. For future explorations, as the range and load-carrying ability increases, Taber predicts increased use of more sophisticated systems for coding the information. Pulse type telemetry systems can be used with transmitting and receiving equipment already in existence; the required modi-

Easy-to-reach TV chassis . . .

Siemens TV set in Germany equipped with folding chassis held by only 2 butterfly screws, which, when loosed permit chassis to fold out to rear for repairs, remains operable during foldout. Design eliminates need for use of screwdriver or soldering iron to reach into chassis. Plug connections lead to important measuring points in back.



fications being in the development of coding systems for use with the appropriate information-gathering transducers. As vehicles go further into space, however, he anticipates that they will pass out of the range of most existing ground-tracking statements so that it will be necessary and feasible to consider other types of systems.

Regarding the possibility of TV transmissions from space vehicles, Taber points out that a broader band width would be needed because of the greatly-increased detail and, since "noise" (signals from sources other than the transmitter) is proportional to band width, much greater power would be required. As for the signals from the Russian satellites, Taber concedes that these are quite complex and could contain a considerable amount of information; but he also points out that sophisticated signals do not necessarily mean that the experiments or measurements on which they are based are equally complex.

The Russians, because of their high-thrust engines, have orbited systems far more sophisticated to transmit "beeps" of considerable significance. Exactly what their significance is cannot be revealed. Although several organizations have worked on the interpretation of Sputnik recordings, publication of their work would give Russian intelligence too many clues indicating our ability (or inability) to crack their undisclosed code. However, certain assumptions can be made regarding these transmissions.

Sputnik signals are a series of interrupted transmissions on the 20 and 40 megacycle band. Each of the pulses exhibited a rising or falling frequency. Duration of the pulse, frequency direction and rate of change may all be significant. So may the interval between pulses. Another possibility is that some sort of commutator arrangement was used so that the meaning of the signals could be classified according to their sequential position. This would also increase the number of different variables indefinitely, the only limitations being the number of transducers available and the permissible time lag.

Still another possibility, since the Russians have proved capable of launching such tremendous payloads, is that the vehicles include equipment for transmitting sophisticated information via complex codes obtained by manipulating the variables listed.

Big Boom in Sprayed Structures

Los Angeles—Over a hundred guns of a new design for depositing glass-fiber-reinforced plastic have been put in operation in the Los Angeles area within the past few months. Manufactured by Peterson Products of San Mateo, California, the unit reduced the time required for lay-up, permits build-up to any desired depth for reinforcing purposes. Several of the major aircraft companies have started experiments with the spray process, and some of the other uses already developed include the coating of the interior of tanks with non-absorbing materials to permit storage of fuel oil or food.

Another reason for the boom, according to Allan Greenwood, general manager of the Fiber-Resin Corporation which distributes the guns and materials and also fabricates a number of products with the equipment, is the simultaneous appearance on the market of isophthallic resins developed by the Oronite Chemical Company. Properties of these are so good that one company (Chemical Process Engineering, Redwood City) predicts that polyester resins will be "out" for most glass-fiber work within a year. Impetus is added to the switch by a recent decision from Wright Field stating that the Air Force will accept the iso resins as the equivalent of epoxy resins for most jobs where structural strength is the primary consideration. Epoxy (MIL R-9300 A) resins sell for 80 to 90 cents per pound. Polyester (MIL R 7575-A-1,2&3) sell for 34½ cents. The iso resins, equal to the epoxies in strength, only cost a penny a pound (35¼) more than the polyesters.

Another advantage to the isophtallic resins is that they have glass-wetting properties "incomparably better than either of the other two resins" according to Greenwood of the Fiber-Resin Corp. He says that the cost of laid-up work with the Peterson gun is about $.50 per ⅛" thick square foot—figuring a one-pound-per-square-foot density. Fabrication with the isophthallic resin takes about 15% less time, he says, because the material is easily compacted due to the superior wetting properties. With polyester repeated rolling is necessary to obtain a dense structure and proper curing. Greenwood points out, however, that the iso resins are not a perfect substitute for epoxies because they do not have the dimensional integrity that is required for tooling applications. Like the polyesters, they have about 4% shrinkage, while epoxy shrinkage is less than would be encountered with metals. However, he also states that the iso resins have a big advantage for all other types of work because they lend themselves readily to spray-gun application.

In the 2-nozzle gun (below), resins from two sources are combined with chopped fiberglass roving spewed out from a special rotating cutting attachment mounted between the nozzles. One supply tank contains resin (either iso or styrene) and an accelerator; the other contains resin and catalyst. Mix ratios in the containers are such that the materials can be stored for as long as 3 days without hardening.

For color application, a tank of resin, color and accelerator is substituted for the resin—accelerator tank and the fiberglass chopper is set to cut the glass into small bits—not over ½ in. long—to produce a smooth coat.

Fiber-Resin says it does not like to try to lay-up color-impregnated material because this creates a possibility of structural defects. When clear resin is used, the matted material has a "frosty" look when deposited but becomes transparent when properly compacted. Air bubbles or unsaturated voids in the layer are immediately evident and can be repaired before the plastic sets up. With the color spray system, or with a gel-coat applied to the mold before layup, the color im-

pregnation is deep enough to be good for the life of the product.

A problem arises in attempting to use epoxies in the gun, because the plastic system is entirely different from polyesters or iso resins. The epoxy must be mixed with a single-function hardener in a precise ratio. This may be anywhere from 5-to-1 to 10-to-1 depending on the particular catalyst; but partial pre-mixing cannot be done because the mix would coagulate. Small variations from the optimum result in failure to catalyze properly; where variations with the other types of resins would merely change the set-up time. Fiber-Resin and Peterson have both experimented with guns designed to handle the wide ratio with the required accuracy. (See PE Feb 23, p 27 for new epoxy spray gun.)

The "Muffin" . . .

is a new axial-flow fan said to have three times the air-moving efficiency of any comparative fan, was recently shown by Rotron Manufacturing Co., Woodstock, N. Y. An "inside-out" squirrel-cage motor and a newly-developed aerodynamic fan-blade design make the product possible. In the Rotron motor the fan-blades are integral with the rotor, which rotates outside the stator instead of in it. A venturi mounting block is provided when air-moving, rather than air-stirring is required. This unconventional construction, end result of two years' development, has a high ratio of diameter to depth—hence its name "Muffin." Motor housing dimensions are 1½ in. deep by 4 11/16 in. in dia. Noise level is 10 decibels lower than a living-room air-conditioner. Applications are expected in electronic cooling, quiet ventilation, and space heaters.

New Lab Speeds Metallurgical Research

WRIGHT-PATTERSON AFB—A new lab for research in refractory and other "difficult" materials is being opened here. The facility is expected to cut time between start of an investigation and publication of results.

Heretofore, process work has been assigned to various organizations with specialized equipment. Such parcelling slowed completion of individual phases of a research program and delayed subsequent stages. With the new integrated facility more effective coordination will be forthcoming, according to Captain Paul S. Duletsky, project officer at the Materials Lab. The lab will be open to other government agencies and organizations under government contract.

Lab is being designed for small quantity production to get samples for metallurgical evaluation. Equipment includes a high-vacuum consumable electrode arc melting furnace, a forge press, an extrusion press, and a rolling mill. With installation of new equipment, the facility will handle materials at temperatures up to 4000 F.

In a typical work sequence, raw material in sponge, shaving or small scrap form will be compacted in a forging press into electrodes 1-in. by 1-in. by 12-in. A number of such electrodes will be welded into lengths up to 6 ft. The welded electrode will then be fed to the consumable vacuum arc melting furnace and melted into ingots. The ingots will be machined to specified size, shape and finish. After heating, these ingots will be forged, extruded or rolled as required. The complete cycle will require one to two weeks.

Previously the work had to be broken up and assigned to various organizations with specialized research equipment in only one field. This meant delay in completing each part of program, and an attendant time lag.

Missile Expert Says Chemical Fuel Won't Put Man Into Space

SAN FRANCISCO—It will cost the US $500 million a year for a program to replace chemical fuel as the power source for successful manned space flight, according to Dr. Louis Ridenour, Chief Scientist for Lockheed Missile System. He told a joint meeting of AIEE and ASME members that chemical fuel can't do the job, and a new system, will have to be invented. He wasn't optimistic that nuclear propulsion would be the answer to the space flight problem.

Soviet Small Car Coming Up

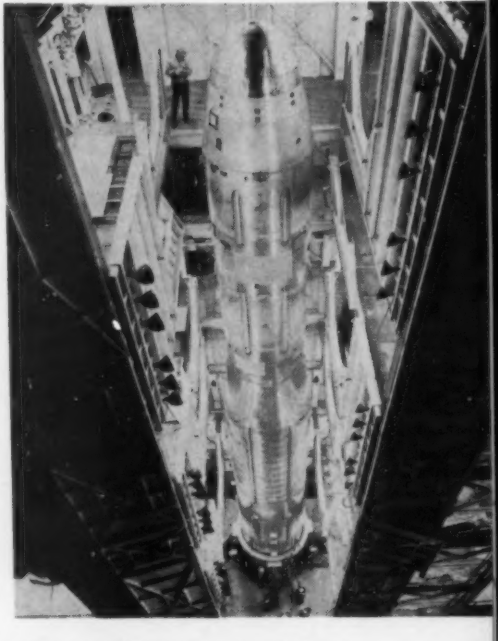
NEW YORK—Reports are filtering into the US concerning Soviet development of a small 2-door, 4-seat car, not unlike the Volkswagen. A prototype has been tested successfully against Russia's traditionally harsh winter weather, and poor road conditions.

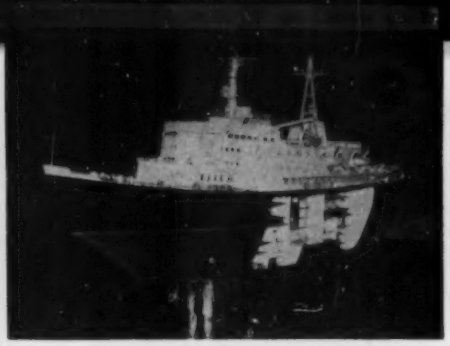
It was reported that the car will weigh about 1,300 lb, will have a 4-speed gearbox, and will be powered by an air-cooled, 4-cylinder, 20-25-hp rear engine providing a max speed of 50 mph. It will have independent wheel suspension. Production now underway in the Ukraine may reach 10,000 units annually by 1965.

Design resulted from lengthy investigation of Italian, German and French cars.

Assembly-line Titan . . .

Martin Co, Denver plant produces Titan ICBM's like this on a prototype (or as Khrushchev calls it, serial basis). Next step, say Martin spokesmen: outer space.





A-powered icebreaker . . .
is reported by Russians to be capable of remaining at sea for an entire year without refueling. SS Lenin is equipped with electric pumps that fill the ship's fore tanks at a rate of 4,000 tons an hr, imparting to the ship a trim bowling that breaks ice more than 2 meters thick. Providing additional strength is the ship's exterior coating equipped with 52-mil-thick ice belt at the bow, 36 mil in midship, and 44 mil in the stern. Power displacement ratio equals 2.75 hp as compared to 2.2 hp for a larger icebreakers. The Lenin develops 44,000 shp with a tonnage of 16,000.

US Firms Seek Share of New Europe Common Market

PARIS—First US reaction to the impending European Common Market appeared in the form of a vigorous sales effort by Bendix Aviation Corp who sent 32 of its engineers here and to Frankfurt, Germany in an effort to woo European manufacturers to Bendix designs.

Some 16 different countries were represented among the more than 1,000 European military officials and businessmen who saw the unprecedented display. The exhibit included aircraft flight control and navigation systems, radar, oxygen and survival equipment, missile systems and components, aircraft landing gear, jet engine controls and starters, meteorological equipment and a variety of electronic devices and components.

Bendix officials report nearly 300 requests for licensing agreements resulted from the project.

Soviets Speed Color TV Development

VIENNA—Color television in the USSR will appear on a test basis during 1959, using Soviet-developed cameras that provide both color and black-and-white telecastings, according to Tass. Programs will be relayed to most Iron Curtain countries, and by 1965 a direct relay system will provide an exchange of programming between all Soviet satellite capitals.

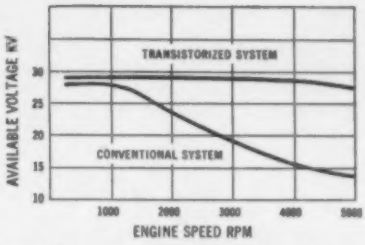
Transistorized Ignition System to Take Lid Off Engine Design

TOLEDO—A high voltage transistorized ignition system which sets free engine design long restricted by conventional ignition systems has been developed by Electric Auto-Lite Co. New system is compatible with existing automotive electrical components.

Contained in a single package, only slightly larger than the conventional ignition coil it replaces, the unit provides maintainable ignition, lifetime distributor contact and eliminates condensers. Blued contact points are eliminated, and constant top voltage can be obtained at all speeds.

Incorporated in the package are the transistor, its heat sink, the transformer and associated circuitry along with two primary terminals and a secondary tower as in an ignition coil.

Basic to the system is an Auto-Lite-designed voltage transformer equipped with transistors where base circuit carries current to be triggered by the distributor contacts, thus timing the firing of the transistor-switched transformer to the engine. Distributor contacts carry greatly reduced load, and react to transistor to set off a chain reaction to deliver greatly increased voltage to the spark plug in the engine cylinder.



Ignition systems, new and old . . .
Output of transistorized ignition system developed by Auto-Lite is compared graphically with that of conventional ignition systems across full range of engine speeds. Transistorized system output is equivalent to a battery ignition system at low speeds and magneto system at high speeds.

The unit is simple to install, and will have immediate application for industrial engines, marine engines, miliary vehicles, commercial fleets, and farm equipment. Automobile officials indicate that the new system will most likely be available as optional equipment on 1961 made cars.

COMING EVENTS

MARCH

8-11 . . . . American Society of Mechanical Engineers, Gas Turbine Div, Engineering Conference and Exhibit, Netherlands-Hilton, Cincinnati, Ohio.

9-12 . . . . American Society of Mechanical Engineers, Aviation Conference, Statler-Hilton, Los Angeles.

16-18 . . . . Society of Automotive Engineers, National Passenger Car, Body, and Materials Meeting, the Sheraton-Cadillac, Detroit, Mich.

16-20 . . . . American Society for Metals, 11th Western Metal Exposition, and Congress, Pan-American Auditorium and Ambassador Hotel, Los Angeles.

MAY

25-28 . . . American Society of Mechanical Engineers, Design Engineering Conference and Design Engineering Show, Convention Hall, Philadelphia.

California to Legislate Against Air Pollution

SAN FRANCISCO—California's Gov. Edmund G. Brown has urged to the state legislature a program to fight air pollution:

1. Require State Dept. of public health to develop and publish standards for the discharge of pollutants from motor vehicle exhausts.
2. Launch a study to determine most efficient system for the inspection of vehicle exhaust discharge.
3. Require State Dept of public health to develop and publish standards for the quality of air created by citizens.

We apologize . . .

If you haven't received your requested PRODUCT ENGINEERING index for the second half of 1958, don't despair. A large demand has made reprinting necessary, causing a 2-week delay in filling requests—The Editors.

Reader To Editor...

'59 Car Design—Revisited

To the Editor:

The article, "Eight Design Authorities Evaluate '59 Cars," aroused a good deal of interest among the group in our office, as I imagine it did everywhere. One aspect, however, impressed me more than any other; this was that the "design authorities" appeared to be interested only in style and appearance, and appeared to have no concern with utility. It seems to be generally agreed that appearance sells cars, and possibly it does, but there must be a reasonable number of people who are not buyers of 5-ton trucks and yet think of utility in a vehicle.—ELBERT G PRICE
Toronto, Ont.

To the Editor:

I feel the Lincoln's classic design actually has no equal. It is not cluttered with over-ornamentation or ostentatious tail fins. I agree with the designers in your article, however, that the 1959 front-end treatment is less attractive than was the 1958. Insofar as the mechanical design is concerned, however, the Lincoln quite possibly perpetrates the most classic fraud on the buying public in a long time. This completely redesigned car apparently has a basic defect in the structure of the body and/or suspension which sets up an apparently non-correctible vibration at speeds in excess of 50 miles per hour.
—P N ADMAS, *President*
Adams Pipe Repair Products
South Elmonte, Calif

To the Editor:

As far as the 1959 cars are concerned, I think all of them are over-chromed, oversized, overpowered and overpriced. I personally am ordering a Lark station wagon for my wife and a Checker sedan for myself. D C MILNER
Akron 2, Ohio

To the Editor:

Any of the five auto companies could keep producing the socalled "monsters", designing them anew each year, while producing a second car for the low-priced market. This low-priced car would use a good design of one or two years ago, for which the die and fixture costs were already amortized, thereby removing a large item in the cost of present cars. This car would be for those of us interested in economical transportation and not the latest style.—HARRISON MACDONALD
De Kalb, Ill

To the Editor:

One gleamed considerable insight into the individual panel designers' philosophies, but virtually nothing about the vehicular designs. Whether good or bad, the products certainly indicate a decadence that has repeatedly shown its face during the last 4000 years of man's reasonably well recorded esthetic expressions. It is amusing that with all the heralding of "function in the nature of materials," etc, the one product that yields so strong an influence on our present culture is deteriorating as rapidly as an over-decorated pine casket. The current-model treatment is reminiscent of the decline of Greek splendor in the Roman hands, of flamboyant Gothic, or more recently, of cast-iron roses in Victorian steam engines. Such decorative themes can be justified, but in this case they exist at the expense of utilitarian function.
—WILLIAM M CAMERON
Manager, Research & Development
Kaiser Aircraft & Electronics Div
of Kaiser Industries Corp

To the Editor:

Modern automobile design has fins that make cars look like fishes. The fish, however, had them for a purpose, not just for looks. My suggestion to the manufacturers is to get rid of all unnecessary fins. I am a Finn myself, and my employers will soon get rid of me too. Old age.
—OTTO SETALA
Carlstadt, NJ

To the Editor:

I don't like being driven around by a bunch of hysterical stylists trying to sell people something they really don't want. I suggest:

1. An agreement among manufacturers about the fenders, i.e. it must be possible to design a grill, radiator or rear end that is not destroyed after a slight bump.
2. An agreement about lights. Same height and width.
3. Removal of all dangerous protuberances (new French law).
4. Better accessibility behind instrument panel. Retractable or revolving.
5. An agreement about place and fastening of the license plates.
6. Hole or bolt for tow rope, but not on the chrome parts.
7. Better material for muffler and tailpipe.
8. Ventilation in which a window can remain open in heavy rains.
9. Drainholes in the doors, to prevent inside corrosion from water that comes in at the window split.
10. A repair book, for the customer, especially for his car, to help him with those small repairs he always tries to do by himself. —G E LIPS
Julianadorp
Curacao, Netherlands Antilles

To the Editor:

An extravaganza of mad designers. No doubt they are appealing to those individuals who must have something that is exotically new. However, some attention should soon be given to that segment of automobile buyers who are interested in economical transportation.
—RALPH H. THEOPHILUS
Morgantown, W Va

To the Editor:

Some of our current designs, the Cadilac in particular, makes me think of a once pretty girl who realizes she is slipping, so she decorates herself until she becomes a floozie. We can be thankful that automobile designers have nothing to do with airplanes or soon it would be unsafe to fly.
LINCOLN K. DAVIS
So. Easton, Mass.

To the Editor:

Based on a purely superficial survey I have still to find something that annoys me more than the "tunnel" in my car. That huge bump running the full length of the car separates the two halves of the vehicle so effectively that it's impractical and uncomfortable to seat anybody over it.
—JESSE GAVALDEN
Carmichael, Calif

To the Editor:

The Buick is the outstanding car of the year, while the Edsel is an abomination; a Cadillac should look distinguished —Loewy's neat but undistinguished.
—HERB STEIN
Pine Bluff Arsenal, Ark

To the Editor:

I believe the German Volkswagen has the maximum number of headlights, fins and amount of trim required.
—C H BERGELAND
Stillwater, Minn

To the Editor:

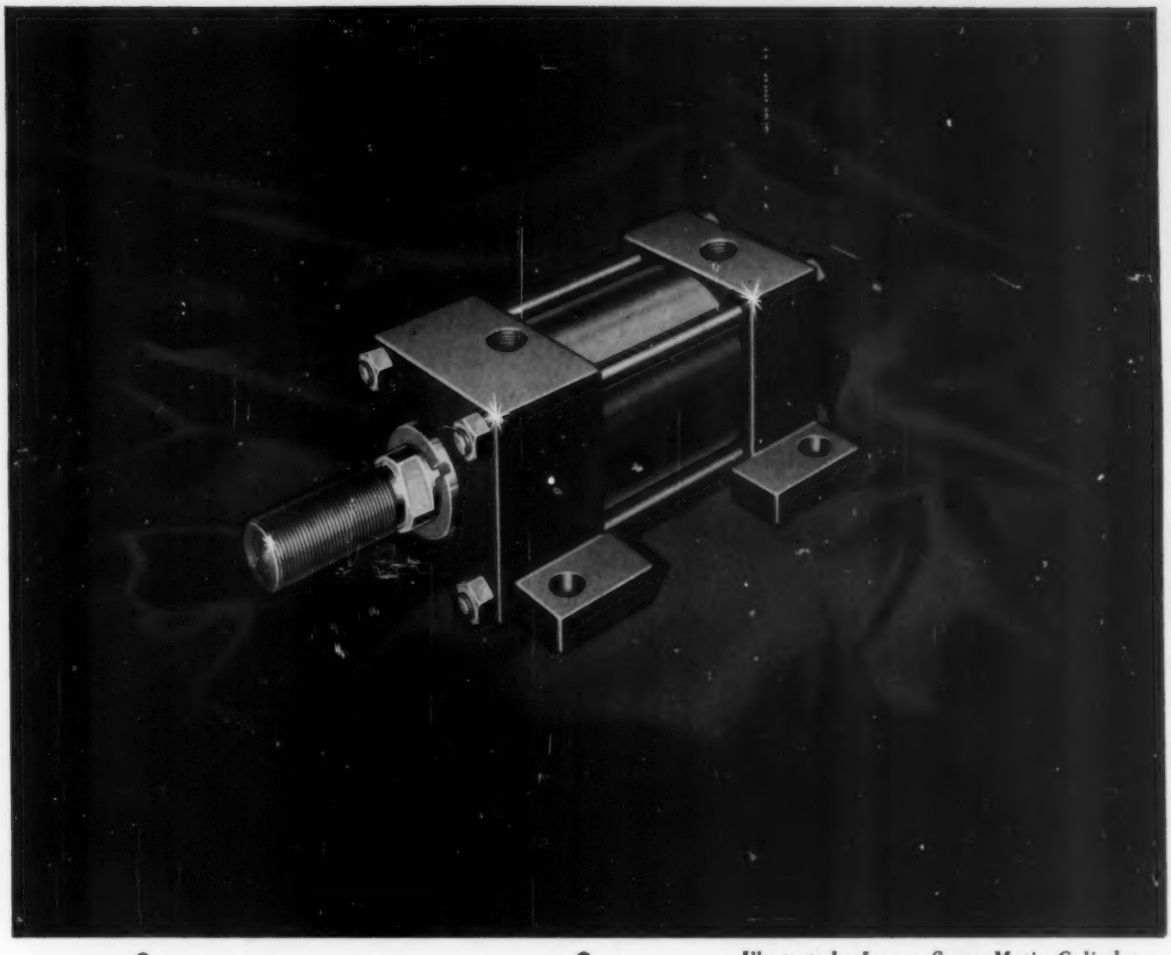
Your hysterical stylists, who contradict each other are in no position to criticise or evaluate the '59 cars. The only sensible statement was made by Teague who suggested starting all over. Why don't we give the industrial designer the problem of redesigning man's anatomy for utilizing his ridiculously styled automobile?
GEORGE DENNIS
Larchmont, NY

To the Editor:

What we need is a car with a 10-year life; an engine you can fix on the kitchen table; and replacement items obtainable at any dime store. —H E WATKINS
Chicago, Ill

To the Editor:

I don't like the 14-inch wheels. I am getting the shortest tire life I have experienced for many years, and feel that braking power has probably been sacrificed also. I don't like the car so low. It is awkward to get in and out of at normal curb heights. I don't like the windshield wrapped around so far. I feel no important increase in visibility has been gained and the post would be far stronger if the knee was taken out of it. Also, this knee and mine often connect painfully when I climb in and out. I don't like red lights instead of meters (probably because I am an engineer). I don't like pushbutton shifting. It is slower, requires visual aid and is more subject to error. The safety interlocks were complex and have failed, and my serviceman has taken them out of the circuits in despair. I wish it used less gas. —W E STEWART
Dayton, Ohio



Illustrated—Logan Super-Matic Cylinder Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic cylinder design

FREE SEND FOR THE "LOGAN CALCULATOR"

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME_____ TITLE_____

COMPANY _____

ADDRESS _____

New CUTLER-HAMMER Synchronous Timers Set the Pace in Industrial Control Timer Design and Performance

One minute timer: Adjustable in one second increments, 0 to 60 seconds.

Three minute timer: Adjustable in three second increments, 0 to 180 seconds.

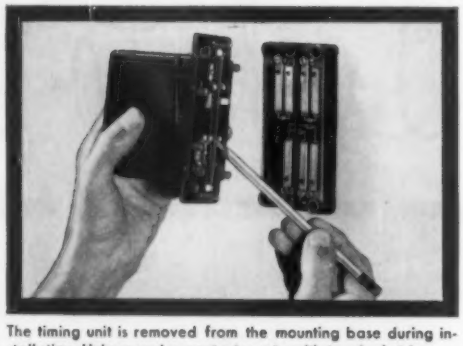
Five minute timer: Adjustable in five second intervals, 0 to 300 seconds.

All three timers are dimensionally identical and feature an exclusive combined terminal board and mounting base. This unique design provides more working-room during installation and on-the-job interchangeability of the timing units without disturbing the mounting base or wiring.

The timer dial reads directly in seconds and one glance shows the exact time delay setting. These timers are simple to set too. Just rotate the bronze pointer to the dial position indicating the precise elapsed time desired and the job is done . . . no approximations or tedious readjustments necessary.

The sweep-second pointer counts off the seconds during each timing cycle. Automatic reset returns the pointer to the start position after each cycle or if a power interruption occurs while in operation . . . no undertimed cycles possible.

These synchronous motor driven timers work better and last longer too. Dust, dirt, and atmospheric conditions can't interfere with the timing mechanism. For further information, write today for Bulletin 10336 E249. CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.



The timing unit is removed from the mounting base during installation. Unique spring contacts mate with terminal strips . . . no inter-wiring necessary. The one, three, and five minute timing units are all the same size and easily interchangeable without disturbing mounting base or wiring.

CUTLER-HAMMER
CONTROL
C-H

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation

FLEXIBLE CONNECTORS, in a variety of sizes, constructions, materials, are designed to meet many working conditions. Our sales representatives in cooperation with our engineering design service will be glad to be of assistance.

BIG space-age problems get BIG flexible metal tube answers

Large-diameter flexible metal connectors in stainless steel and other alloys—to handle expansion and contraction, wide range of temperatures, corrosive fluids, high pressures, and vibration.

Jet engines, modern chemical plants, rockets, atomic energy plants have created a new technology that calls for new products. The American Metal Hose Division of The American Brass Company is constantly working with design engineers on special flexible connector assemblies to meet new problems.

Equipped to work in stainless steel, Monel, and aluminum as well as in other alloy steels and copper alloys, these Anaconda specialists welcome the opportunity to help you get the flexible metal hose you need to meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures.

FREE TECHNICAL SERVICE. For engineering assistance on special products—or for a free copy of our General Catalog showing the full line of standard American Flexible Hose and Tubing products—write: The American Metal Hose Division, The American Brass Company, Waterbury 20, Connecticut.

WHEREVER CONNECTORS MUST MOVE

AMERICAN
FLEXIBLE METAL HOSE AND TUBING
an
ANACONDA®
product

THE AMERICAN BRASS COMPANY PRE
American Metal Hose Division, Waterbury 20, Conn.

Please send me your free, 60-page General Catalog containing basic information on all types of metal hose and tubing, fittings, etc.

NAME & TITLE .....

ADDRESS .....

COMPANY .....

CITY, ZONE, STATE .....
(PLEASE PRINT OR TYPE)

A BETTER START

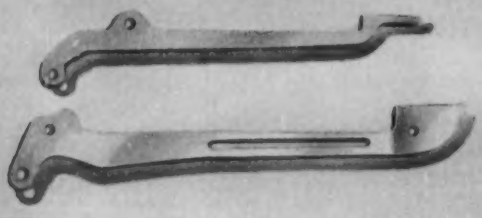
for YOUR product with

Cold Rolled Spring Steel

HERE'S HOW A "BETTER START" MADE THESE PRODUCTS BETTER:

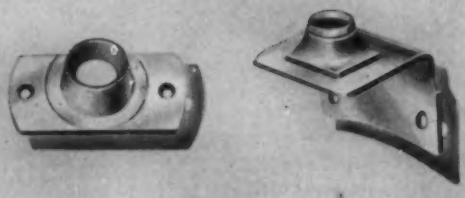
BUSINESS MACHINE PARTS:

- Eliminated grinding for gauge accuracy
- Improved stamping properties
- Reduced warpage in heat treatment
- Improved forming qualities



FASTENERS:

- Improved drawing qualities
- Reduced rejects
- Lowered production costs
- Cut quality control costs



COLD ROLLED SPRING STEEL MET THESE RIGID SPECIFICATIONS:

ANALYSIS: AISI 1055 • **ROCKWELL:** B 85-95
MICROSTRUCTURE: Uniform grain structure and carbide distribution
GAUGE TOLERANCE: ± .0003" including crown
WIDTH TOLERANCE: ± .005"
SIZE: 2" x .0384"
FINISH: No. 2 • **EDGE:** No. 3
COIL SIZES: 200/250 lbs. per in. width

ANALYSIS: AISI 1045 • **ROCKWELL:** B 72 max. Deep drawing qualities
MICROSTRUCTURE: Well rounded and uniformly distributed carbides in a ferrite matrix
GAUGE TOLERANCE: ± .001"
WIDTH TOLERANCE: ± .005"
SIZE: 1½" x .020"
FINISH: No. 2 • **EDGE:** No. 3
COIL SIZES: 200/250 lbs. per in. width

Starting with a better material – quality controlled to *your* exact specifications for the product you make – assures a *better* product – with *important savings* to you.

J&L is your most dependable source for *quality controlled* cold rolled spring steel to standard specifications – or to meet the most exacting demands of your product's custom specifications.

Give your product that all-important "Better Start". Contact J&L today.

Plants and Service Centers: Los Angeles • Kenilworth • (N. J.) • Indianapolis • Youngstown

STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

NEW *from* SEALMASTER®

QUALITY
PERFORMANCE
ECONOMY
The "LP" Pillow Block
• Precision self-aligning one-piece unit. No extra assembly costs for you.
• Malleable housing provides maximum strength with light weight.
• Permanently sealed—prelubricated with high grade lubricant.
• Nothing of comparable value in low price field.
"L" & "SL" BEARINGS
"L" BEARING
"SL" BEARING
SEALMASTER
BALL BEARING UNITS
Write for Bulletin 1058

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 9 RIDGEWAY AVE., AURORA, ILLINOIS

←CIRCLE 115 READER SERVICE CARD

CIRCLE 116 READER SERVICE CARD

Can a better spring save you money?

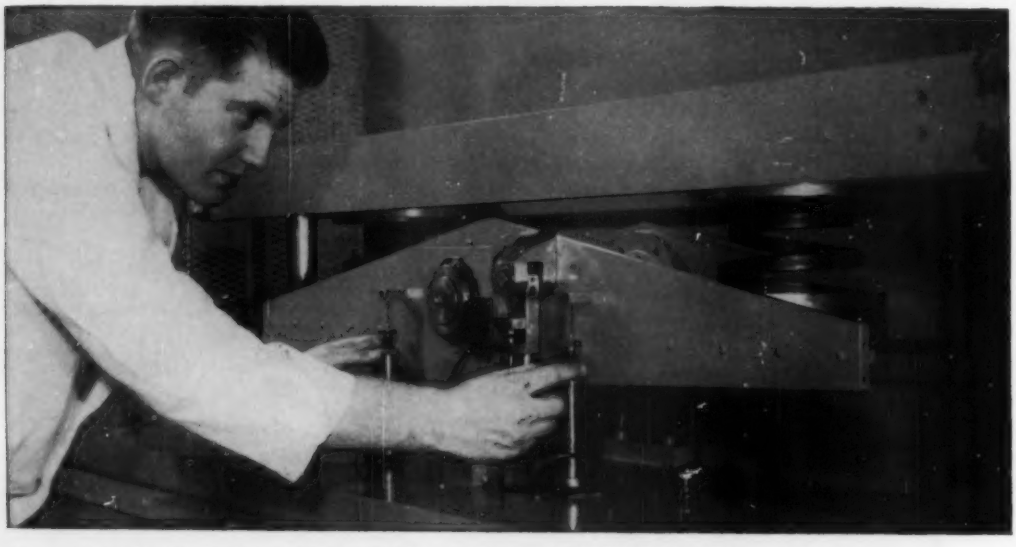
. . . then put American Spring Engineering Research Service to work for you!

WOULD you like the springs you now use to last longer? Would you like to cut their cost? Do you need design assistance on a difficult new spring application? *American Steel & Wire may be able to help you.*

We maintain complete spring testing facilities to help you solve any spring problem. Our spring engineering specialists can help you improve the *design* of your spring. We can help you determine the best possible *steel* to use. Then, we can completely check spring performance. We can simulate any spring operating condition and verify these recommendations in terms of improved service in your product.

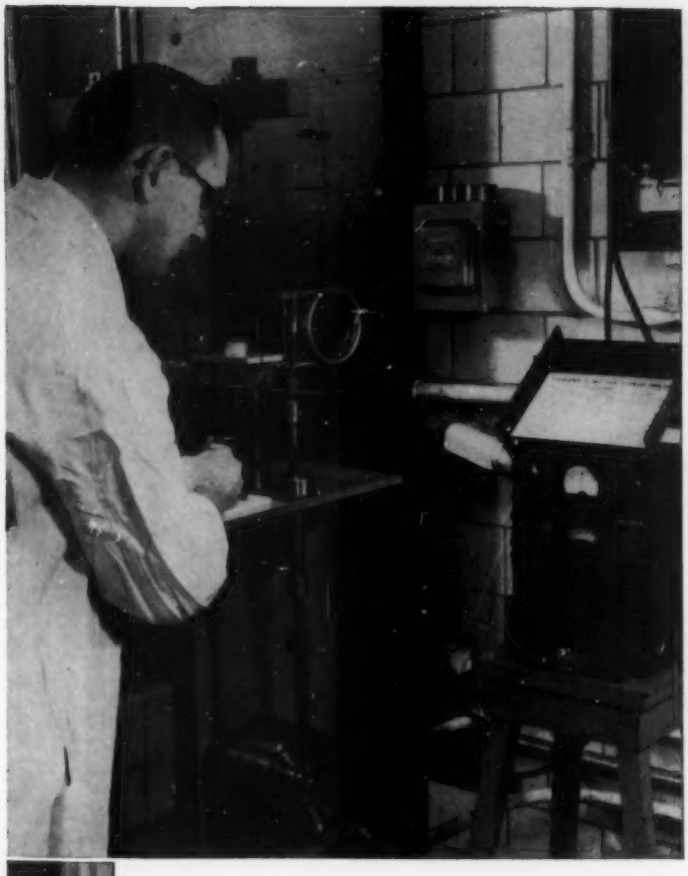
Hundreds of companies have taken advantage of this service and have profited from it. Why don't you? Just write American Steel & Wire, 614 Superior Avenue, N. W., Cleveland 13, Ohio.

USS is a registered trademark



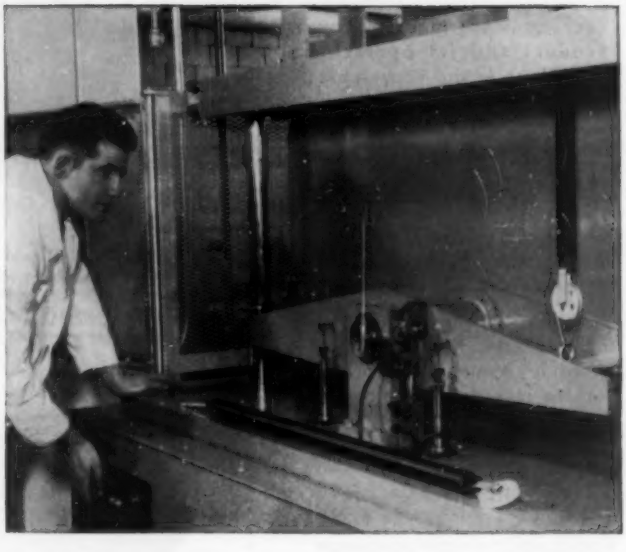
Heavy-Duty Clutch Springs Last Longer Now—Thanks to AS&W Spring Research!

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, New York, asked AS&W Spring Engineering Research Service to determine if design change would lengthen the life of the flat wire compression springs used in their clutches. AS&W recommended design changes that greatly increased the spring life.



AS&W Spring Tests Make Possible New Design Rocking Chair!

40,000 springs—not one failure—American Steel & Wire helped Homecrest Company, Wadena, Minnesota, design a round wire helical torsion spring for an unusual new type of swivel rocking chair. To date, 20,000 of these chairs have been sold, but not one failure of the 40,000 springs has been reported.



Design Change Increases Operating Life of Garage Door Springs!

The Steel Door Corporation, Birmingham, Mich., asked the AS&W Spring Engineering Research Service for a statistical evaluation of the fatigue life of this extension hook-type spring. As a result of the test, AS&W recommended a design change which has materially lengthened the operating life of the spring.

American Steel & Wire Division of USS United States Steel

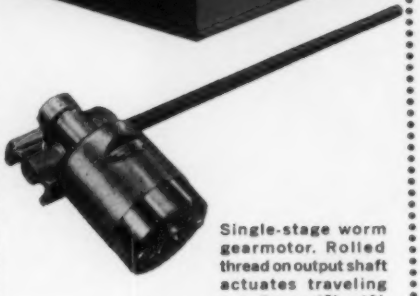
Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

You Design Dependability Into Your Power-Driven Product with...

Lamb Electric®

SPECIAL APPLICATION
FRACTIONAL HORSEPOWER
MOTORS

Impact drill motor for putting threaded inserts in concrete. Designed to withstand heavy vibration. Frame 3 11/16 x 1¾



Single-stage worm gearmotor. Rolled thread on output shaft actuates traveling nut. Frame 2⅞ x 1⅜

Two-stage helical gearmotor with crank on output shaft to operate circuit breaker. Frame 2⅞ x 1½

Three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader. Frame 4⅜ x 2⅛

Thorough study by our engineering department of your product and its operating conditions is the first step in designing a Lamb Electric motor that will assure required dependability.

The next step is translating this information into a motor design having the electrical and mechanical characteristics needed for your particular application.

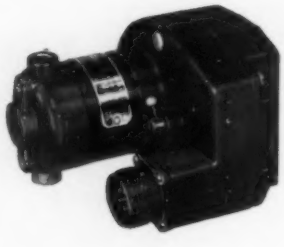
We then custom manufacture the motor on a volume basis to obtain high quality, uniformity and the most favorable cost.

May we discuss these advantages of Lamb Electric motors with you?

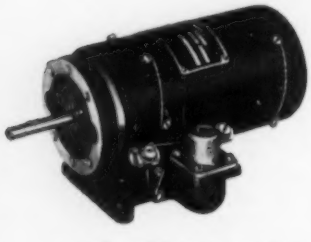
THE LAMB ELECTRIC COMPANY
Kent, Ohio

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ont.



24 Volt DC fuel valve actuator incorporates gear train torque-limiting clutch and limit switches. Frame 1⅝ x ⅝



Totally enclosed fan-cooled 27 volt DC motor for pump drive. Frame 2 x 1½

Heavy duty motor for industrial vacuum cleaners, colloid mills, hoists, etc. Frame 6 x 2½

Another exclusive K&E *development...*

With new PHOTACT® Polyester Films you can make second originals—USING ORDINARY PAPER DEVELOPER

Available in 3 types:
PHOTACT Polyester Film, Contact — 409
PHOTACT Polyester Film, Direct Positive — 411
PHOTACT Polyester Film, Projection — 419
... all three with excellent drafting surface on both sides.

Now, for the first time, you can make photographic second originals *on film* without the fuss and bother of using special, short-lived, expensive developers. With new PHOTACT Polyester Films your regular paper developer does the job perfectly. Think what that means in terms of lower inventory — less cost — simpler operation.

With these new films you get all these other advantages ...

... **Blacker blacks,** because PHOTACT film has a higher silver concentration than comparable film.

... **Durability,** wrinkle-proof — you can actually crumple a drawing on new PHOTACT Polyester Film into a ball, smooth it out, and still make a perfect reproduction.

... **Won't yellow** with age — or from repeated trips through the machine.

... **Quick drying** because these films are virtually waterproof.

... **Faster prints** due to greater transparency.

... **Better than original copy** — reproducibles from old yellowed drawings drop out stains, creases — strengthen detail.

These exceptional new films are part of a complete line by K&E — specialists in reproduction films, papers and cloths. See them now at your K&E dealer's. Or send in the coupon below for free samples and literature.

KEUFFEL & ESSER CO. Dept. PE-3 Hoboken, N. J.
Send me free samples and literature on new PHOTACT Polyester Films:
☐ Contact-409 ☐ Direct Positive-411 ☐ Projection-419

Name & Title: _____

Company & Address: _____

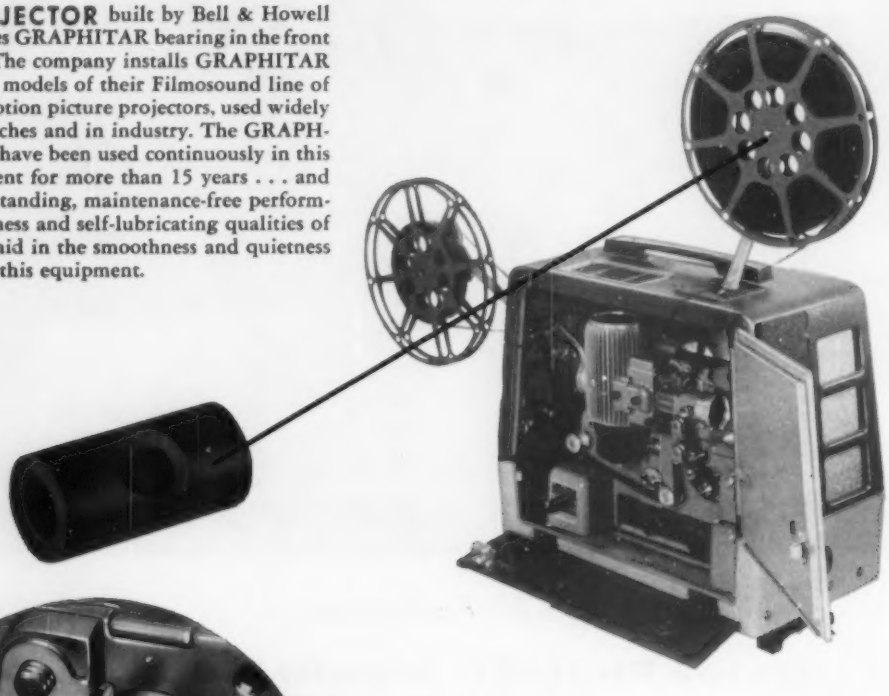
_____ 1925

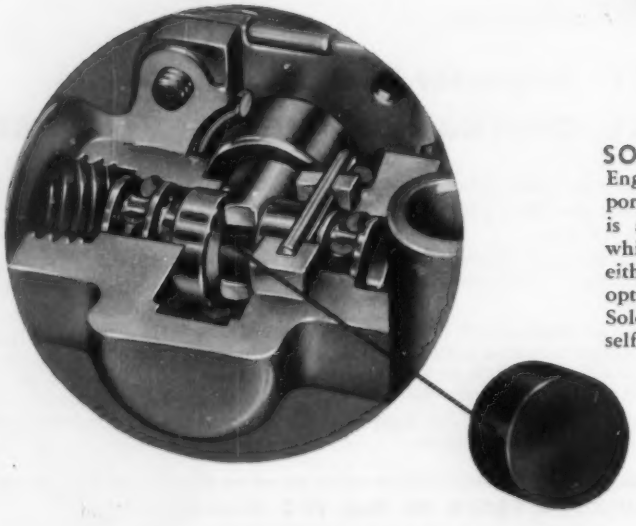
this is GRAPHITAR®

(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.

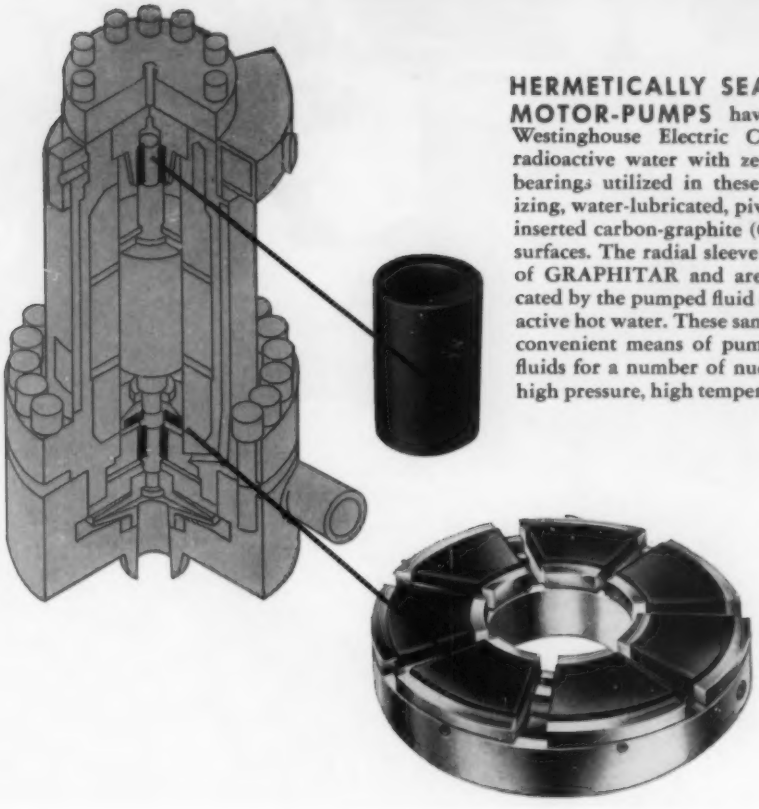




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

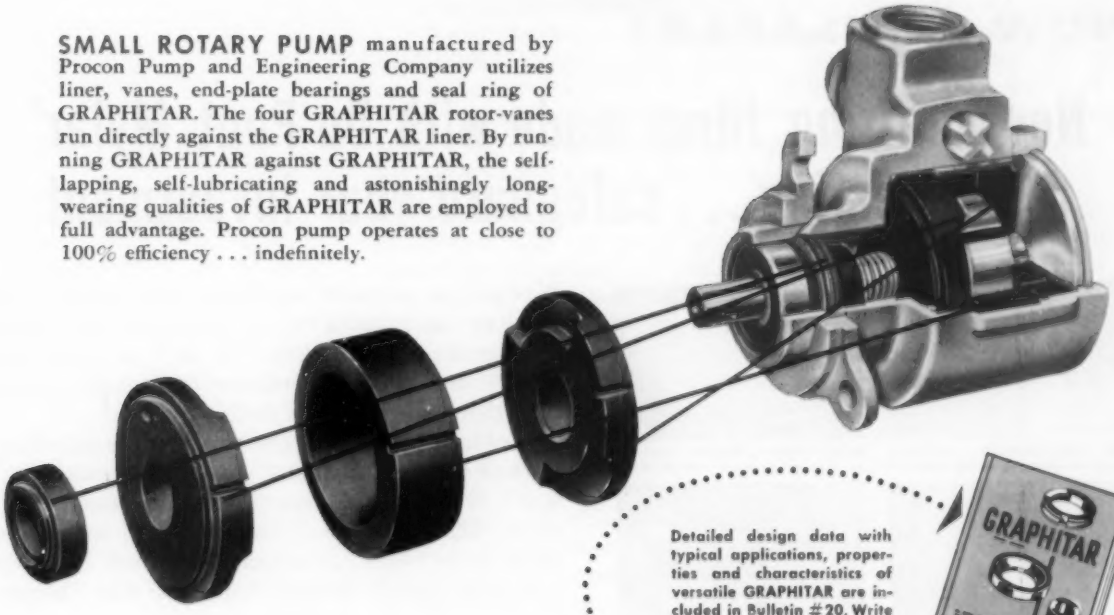
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

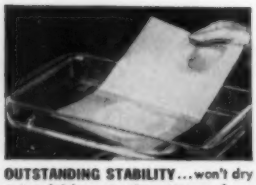
GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

NOW AVAILABLE!

New drafting films made with Du Pont Mylar® resist tearing . . . safeguard your investment

HIGH TEAR STRENGTH . . . withstands roughest handling, many reproductions.



OUTSTANDING STABILITY . . . won't dry out or shrink . . . remains waterproof.

SUPERIOR TRANSLUCENCY . . . faster, more accurate printing . . . fiber-free.

GREATER FLEXIBILITY . . . rolls up repeatedly without cracking . . . lies flat.

Now you can safeguard your investment in costly original drawings by using the new pencil and ink drafting films made with Du Pont "Mylar"* polyester film. What's more, these tear-resistant drafting films *cost no more* than many grades of cloth!

Look at the remarkable combination of benefits found in these new drafting films! They resist cracking . . . won't embrittle with heat used in reproduction . . . won't yellow with age . . . won't soak up moisture or grease from hands . . . remain waterproof. Next time you order, specify drafting film made with "Mylar."

*"Mylar" is a registered trademark for Du Pont's brand of polyester film. Du Pont makes the base material "Mylar"—most leading manufacturers of drafting materials are now offering pencil and ink drafting films made with Du Pont "Mylar".

SEND FOR FREE SAMPLES. To provide you with an opportunity to test various samples, we will ask the manufacturers to send you a sample of their own brand of pencil and ink drafting film now made with "Mylar". For your samples, write E. I. du Pont de Nemours & Co. (Inc.), Film Department, Room P-3, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . *THROUGH CHEMISTRY*

DU PONT MYLAR® POLYESTER FILM

PERSPECTIVES

in design and development . . .

Unity in Western Europe

Armaments, economics and politics are pushing Western Europe towards unity at a startling pace. Since Jan 1, French and West German military authorities have agreed to jointly design and build a medium transport plane; France, Germany, Italy, Holland, and Belgium have collectively decided to produce the US anti-aircraft missile, Hawk; and first substantive clauses of the Common Market have come into operation.

It is understandable why Americans might be skeptical. The past has seen so many such moves toward creating a United States of Europe! But US businessmen have given the Common Market their accolade in increasing numbers by establishing manufacturing facilities within its frontiers.

Taken at its lowest face value, the European Economic Community, as it is known, will provide a full customs union of France, West Germany, Italy, Belgium, the Netherlands and Luxembourg by Jan 1 1973 at the latest. This customs union, with its barrier to the outside world, has been the practical motivation for American producers getting inside the wall, and it is this aspect of the Rome Treaties of 1957, which also established European Atomic Community (Euratom), that has received most attention.

Seen from the European Economic Community's temporary headquarters in Brussels, however, customs union is only one essential part of the whole; the whole being no less than eventual economic and political federation.

The requirements of modern military defense—from planning through R & D to production and procurement—are the sharpest argument against staying with purely national programs. Still, pride and tradition in countries around the world are slow in yielding. So, the establishment of a joint French-Italian-German armaments pool last year, and its first major result 12 months later in agreeing to the above-mentioned Franco-German transport plane, is close to revolutionary.

US Reliance on Europe R & D

A logical consequence will be greater US reliance on R & D facilities of European allies and procurement of European-designed and produced material for US forces there. This principle was set at the NATO Summit meeting Dec 1957, but its realization did not automatically follow. Commercially, the trend has been growing in the past five years.

The success in piloting the European Economic Community through the shoals of French resistance has been accompanied by the foundering, at least temporarily, of a larger Free Trade Area centered on the Common Market. However, even this has had some rewarding side-effects. For example: to avoid a trade war, 10 European countries, led by Britain, introduced full dollar convertibility for foreigners just prior to Jan 1.

How much real competition there will be within the Common Market is a critical question. Industries in each of these countries have shifted capital investment from expansion to modernization, presumably to be fitter and leaner for the struggle. But there has been a suspicion throughout that in the end, precepts of "accomodation," rather than "survival of the fittest" will prevail—with a consequent loss to technological incentive in less efficient national industries. In the parallel battle on cartels, the cartelists argue that bigness is simply a necessary mark of the times and that compared to the Americans and Russians, the West Europeans are comparative pygmies. The recent approval for Alfred Krupp to increase his steel domain has been the most publicized of such mergers, but it is not the last, nor even the biggest. —Morrie Helitzer, Bonn

Another Tinnerman Original...

Cost-cutting Tubular **SPEED CLIP**® takes positive "bite" to hold assemblies tight!

In seconds, you can front-mount trim, name plates, grilles, knobs, insulation, with Tubular SPEED CLIPS. And at interesting savings in assembly time and costs!

Snap these quality spring-steel fasteners into holes in metal, plastic or wood. Then press the mounting studs, nails or rivets into the clips to complete the attachments... anywhere along your assembly line.

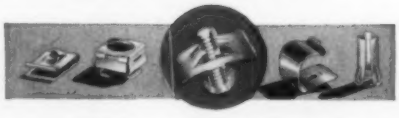
As the SPEED CLIP is inserted, spring fingers compress, then expand behind the panel to lock tight. The rolled-in end permits easy entrance, but bites hard into the stud to prevent back-off or vibration-loosening.

Tubular SPEED CLIPS are available for a full range of stud sizes and panel thicknesses. Permanent lock or removable types.

Check your Sweet's Product Design File (Section 8/Ti) for data on Tubular SPEED CLIPS and other SPEED NUT brand fasteners. Then call your Tinnerman representative for samples and additional information. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®



FASTEST THING IN FASTENINGS®

CANADA: Dominion Fastoners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Product Engineering

HORIZONS

March 2, 1959

Engineering
— the un-noted catalyst

When I was in college, we had a saying that "the student who can't pass engineering gets his degree in science." There were several cases in my own class. Thus it is with some confusion that I find the currently popular word for advances and careers is "science."

Does this mean that our advances are being made by the theoreticians and the "failures"? Are the men at Cape Canaveral and back in the rocket-buikding plants scientists? Is Dr. Glennan a scientist or Lloyd Berkner, chief of the Space Science Board, or Wernher von Braun? All these are engineers–with engineering degrees. But "scientist" is the word the newspapers scream and the laymen invoke.

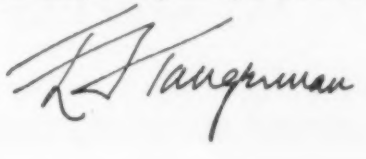
The question would be purely academic, were it not for the fact that "science" is taking on world dimensions. After a year of stalling, the State Department has begun appointment of science officers for our embassies. The first include a chemistry professor, a physical chemist, and a zoologist. If these people function as attaches–as they must–and have an effect upon foreign policy and our contacts with foreign "scientists", hadn't we better get a practical man, or two, or three, into the program? What contact do we really want–scientific or engineering?

"Science" is an omnibus word, covering practically anything done with method, from zoology and medicine to mathematics and mixing paint. The term "scientist" can presumably be used by anyone with a degree of bachelor of science, which could be in physical education, home economics, botany, or a hundred other "disciplines" depending upon the custom of the graduating institution. Like "engineer", the word "scientist" can cover a multitude of sins, but the multitude is larger.

Obviously called for is some soul-searching by engineers. There must be more than talk about unification of engineering groups. There must be some re-evaluation of the prodigality with which the word "engineer" is allowed, both in industrial work classification and in society membership–associate or otherwise. And there must be more realization that it is engineering, and not science, that made the atom and hydrogen bombs, that can deliver them, that puts a satellite into orbit. It is also engineering that develops and makes our everyday products, that delivers our power and heat.

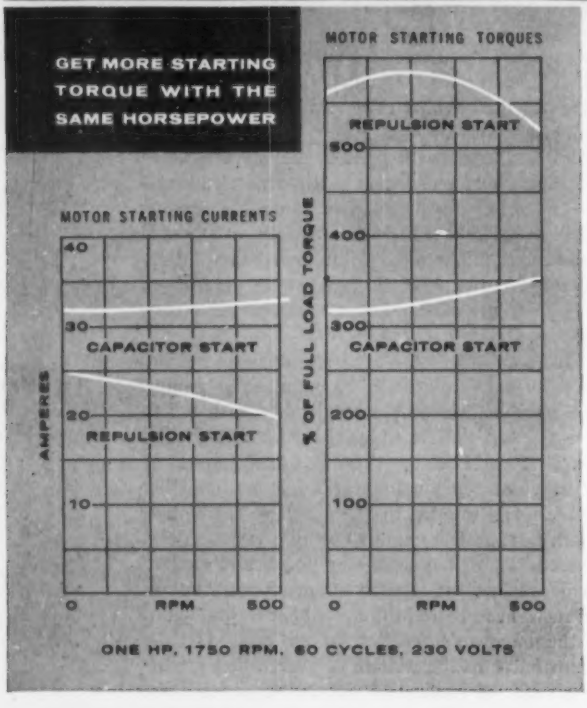
Labor, too, has made much noise recently about its contribution to the product, about its right to share in the profits of technological advance. What of the engineer's position in all this? Has he become the silent contributor to the welfare of every other group?

Seemingly, in the advance of civilization, international relations, domestic relations, and plain, ordinary income, the engineer has become the anonymous catalyst. Science, labor, diplomacy, or some other omnibus name gets the credit, but engineering does the work.



TOUGH STARTS MADE EASY...

WAGNER REPULSION-START INDUCTION MOTORS



START HEAVY LOADS WITH EASE

STAND UP UNDER LONG SERVICE

USE EXTREMELY LOW STARTING CURRENT

Starting heavy loads is a natural for Wagner Type RA Motors. Widely used for high starting torque applications, like farm machinery, compressors, pumps and grinders, this rugged single phase motor requires very low starting current that minimizes light flicker. You get smooth performance with a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough single phase applications with these motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

You can get these motors from leading motor distributors in your community or through Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-220 gives full details on Repulsion-Start-Induction Motors.

WM59-8

Wagner Electric Corporation

6406 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

SERVING 2 GREAT GROWTH INDUSTRIES ... ELECTRICAL ... AUTOMOTIVE

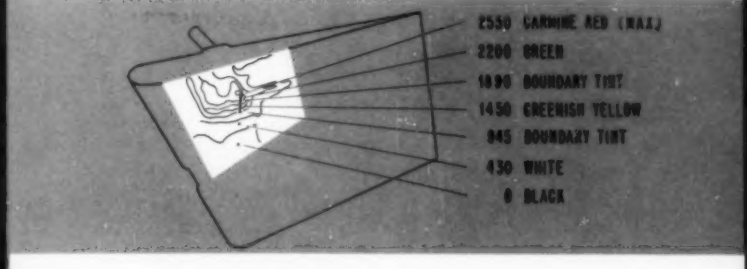
make strain visible
... with

PHOTOSTRESS ANALYSIS

DR FELIX ZANDMAN Director of Basic Research
Tatnall Measuring Systems Co Subsidiary of The Budd Co

Dr. Zandman developed this PhotoStress technique for observing and reading strains in structures and parts under load. It is done with a double-refracting plastic applied as a coating or a cemented film. Presented in this article are current, practical applications for the method, including a torquemeter. For theory behind the method, see "PhotoStress," Sep '56, p 167.

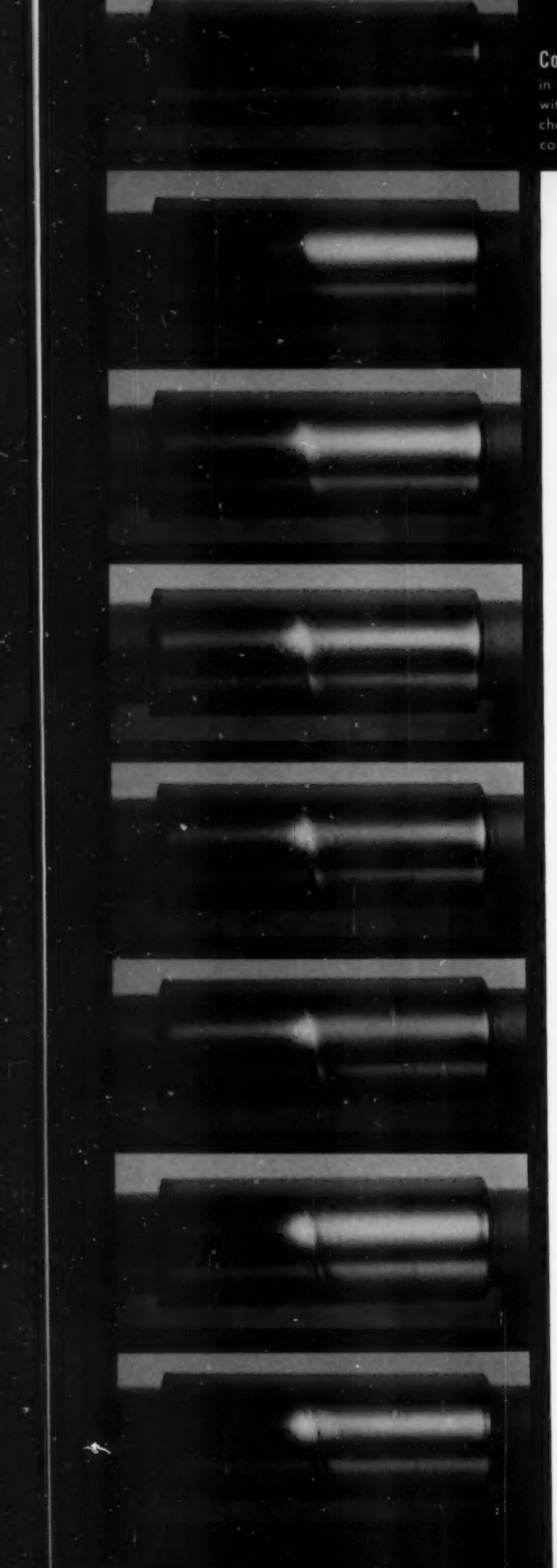
A thin coating of special double-refracting plastic, cemented to the actual part, will follow every surface strain – acting like an infinite number of tiny strain gages. Then, when polarized light is reflected by the coated part and viewed through a polarizing instrument, you get color patterns that can be interpreted quantitatively in terms of surface principal strains – within 10 microin/in. High strains up to rupture of part can be investigated–from the yield patterns remaining. Stress can be calculated from strain, and directions of principal stresses can also be determined (see "Review of Theory," p. 45). Almost any structure or part – made from almost any material–can be coated with the spe-



These sample readings...
interpret color fringes in test rudder, bottom view.
Strain values ($\epsilon_1 - \epsilon_2$), microin/in., were read from color chart.

COPYRIGHT 1959
THE McGRAW-HILL PUBLISHING CO., INC.

Surface strain...
is determined from color fringes in special plastic coating when test panel is strained and examined under polarized light. Panel is full-scale feasibility test section of a proposed rudder for Convair's F-106 supersonic interceptor aircraft and is of integrated-core construction, a Budd Co proprietary development. Panel in top view is unstrained; center, moderately strained; bottom, highly strained.



Color means strain . . .
in these photographs of a 1-in.-dia aluminum shaft under torque, taken with polarized ordinary white light. By matching colors with those on color chart, torque can be estimated within 10% of true value; with color compensators to 1%; and with PhotoStress torquemeter to better than 0.5%.

Color vs stress and strain

(ϵ_1, ϵ_2 are principal strains; σ_1, σ_2 are principal stresses)

	TYPICAL SEQUENCE	$\epsilon_1 - \epsilon_2$ MICROIN/IN.	$\sigma_1 - \sigma_2$, psi STEEL	$\sigma_1 - \sigma_2$, psi ALUMINUM
1st spectrum	black	0	0	0
	gray	170	3,900	1,300
	white	430	9,900	3,300
	pale yellow	460	10,600	3,500
	light yellow	500	11,500	3,800
	orange	720	16,600	5,500
	reddish-orange	840	19,400	6,500
	red	900	20,800	6,900
	boundary tint	945	21,700	7,200
2nd	indigo	980	22,600	7,500
	blue	1,100	25,400	8,500
	green	1,250	28,800	9,600
	greenish-yellow	1,450	33,500	11,200
	pure yellow	1,520	35,100	11,700
	orange	1,670	38,600	12,800
	dark red	1,830	42,300	14,100
	boundary tint	1,890	43,400	14,400
3rd	indigo	1,910	44,000	14,700
	green	2,200	51,300	17,100
	greenish-yellow	2,380	55,000	18,300
	carmine red	2,550	58,900	19,600
4th	boundary tint	2,835	65,000	21,700
	green	2,900	67,000	22,300

This color sequence is for crossed polarizers at 90°. Plastic is 0.12-in. coating of Tatnall type *S* or *A*. For other thicknesses, multiply values of strain and stress by $0.12/t$, where t is actual thickness in inches. Stress values apply only when the part is not stressed beyond the elastic limit.

Example: In next-to-bottom shaft (series at left) yellow corresponds to "pure yellow" in chart. Value for $\epsilon_1 - \epsilon_2$ is 1520 microin/in.; $\sigma_1 - \sigma_2$ (for aluminum) 11,700 psi. Torque is:

$$T = \left(\frac{\pi}{16}\right)(\text{dia})^3 \left(\frac{\sigma_1 - \sigma_2}{2}\right) = 1150 \text{ in.-lb}$$

cial plastic. Aluminum, steel, wood, concrete, glass, rubber, plastic, and stone are but a few.

Uniform strain will show uniform color. Nonuniform strains and especially stress concentrations will show patterns (fringes) of color. The strain can be read from the color chart on opposite page, or more accurate color compensators can be used. Many structures and parts difficult to measure by usual means have been successfully handled with the PhotoStress technique. For example:

- Welded pressure vessel – different spotwelding methods and spacing arrangements were compared.
- Reinforced concrete bridge – the plastic sheets, bonded to supporting sections during construction, measured effects of increasing weight of the bridge and shrinkage of the concrete. Later, normal stress distribution was measured with the addition of live loads; and readings, taken every three months, disclosed changes with time.
- Automobile shaft – average values of torque on the running crankshaft of a 4-cylinder engine, using the dual-polarizing instrument shown here. An oscilloscope display of output from the instrument – modified for purpose – clearly showed torque pulses from individual cylinder explosions.
- Airplane wing – visual observation of stresses on wing of Douglas DC-7 during flight (without any external instruments) using a special polarizer applied directly to the plastic coating, with daylight as the source of illumination. Varying color fringes were observed as the result of strains during fueling, taxiing, takeoff, and flight. In before-and-after tests on a jet fighter a permanent strain pattern showed where yield had developed during the flight.

Continuous torque measurement of a rotating shaft is possible with the PhotoStress method, with no physical contact between the shaft and instrument. Because a cylindrical shaft has uniform strain in torsion, the coating produces uniform color of light, the color changing with the strain. The strain in a rotating shaft can be read continuously through an optical instrument. Sliprings and a shaft section of special dimensions – common requirements for the strain-gage method – are not needed. Any normal shaft surface can be easily prepared for the plastic coating.

HOW TO MEASURE TORQUE

Simplest instrument is a reflection polariscope in which the color and intensity of the light viewed is measured visually against the accompanying color chart, measured with a calibrated optical compensator, or detected with a photocell. Response speed is instantaneous – 30,000-cps vibrations can now be recorded – and a photocell has good sensitivity. Variations in ambient light, filament temperature, power supply, and photocell sensitivity will make frequent zero adjustment necessary. Temperature changes and aging may in time affect refraction properties of the coating.

Compensated polarizing instruments, such as the dual-channel transducer described here, eliminated effect of ambient disturbances but response is slowed to 20 cps max because of moving parts.

Requirements applying to both methods of measuring torque are: shaft must be accessible to instrument; temperature must remain between –40 and 100 F or temperature correction will be needed; shaft and lens objectives of instrument must be kept free of dust or oil.

REVIEW OF THEORY

When polarized light goes through strained double-refracting plastic at normal (90°) incidence, the color change (measured with a polarizing instrument) is proportional to the difference between principal strains, $\epsilon_1 - \epsilon_2$. The difference between principal stresses, $\sigma_1 - \sigma_2$, is equal to $(\epsilon_1 - \epsilon_2)\left(\frac{E}{1+\mu}\right)$, where μ is Poisson's ratio and E is modulus of elasticity of the coated part. Max shear stress, τ_{max}, is $\frac{1}{2}(\sigma_1 - \sigma_2)$.

For principal strains equal in magnitude but of opposite sign (shaft subjected to torque) each principal strain and stress is easily calculated:

$$\sigma_1 = -\sigma_2 \; ; \; \sigma_1 - \sigma_2 = 2\sigma_1$$
$$\sigma_1 = -\sigma_2 \; ; \; \sigma_1 - \sigma_2 = 2\sigma_1$$

If principal strains are unequal (general case) and separate values of σ_1 and σ_2 as well as max shear stresses must be measured, then an oblique (in addition to the normal) incidence light-reading must be taken with a polarizing viewer. The theory is given in the previous article, "PhotoStress", mentioned above. However, in areas of peak stresses such as around holes, notches or other free boundaries, the principal stress normal to the boundary is equal to zero. Therefore a normal-incidence reading gives the other principal stress directly. Directions of principal stresses can be determined by "isoclinics" – black fringes – also covered in the previous article.

Comparative Performance of Torquemeters

	PHOTOSTRESS	TYPICAL STRAIN-GAGE
Sensitivity, % full scale	0.05	0.3 to 0.05
Accuracy, % full scale	0.5 or better	0.3 to 1
Temperature, max °F	250	250
Speed, max rpm	Almost no limit	3000
Eccentricity allowed	± 2% of dia	± 0.0015 in.
Range, microin/in.	200 to 4000 (0.12-in. plastic)	1500 for each gage
Response time, sec	1.5 (full scale)	Depends on design

PhotoStress torquemeter . . .

uses dual polariscope transducer to measure intensity of polarized light from plastic-coated rotating shaft. This reflected light reaching the photocell from the bonded section changes color with torque. Light from the unbonded (unstrained) half is reference for the variable half.

Optical system works like this: (a) lamp filament illuminates duplicate polarized-lens systems, sending beams of equal intensity to each coating; (b) each beam passes through the coating and reflects back, but only the beam from the bonded coating is subject to change in color and intensity; (c) both beams go to the double mirror vibrating at 60 cps; (d) and beams are alternately reflected to the photocell.

As long as both beams have equal intensity, photocell pulses at 120 cps. With unequal beam intensities, the output becomes a 60-cps disturbance. An electronic control circuit (not shown) tuned to 60 cps produces a servo control signal to rotate a lead screw which moves an optical-wedge compensator. This wedge, which is double-refracting, moves in the beam coming from the bonded plastic until the photocell again receives identical light intensity from each side of the system. Final output — a useful signal — is the mechanical movement of the lead screw. It turns a counter and positions a potentiometer.

During operation there is no physical contact between torquemeter and shaft; the V-blocks only aid in initial positioning of the instrument. Equipment combining the torquemeter and a tachometer gives continuous reading of power.

EDITOR'S NOTE:

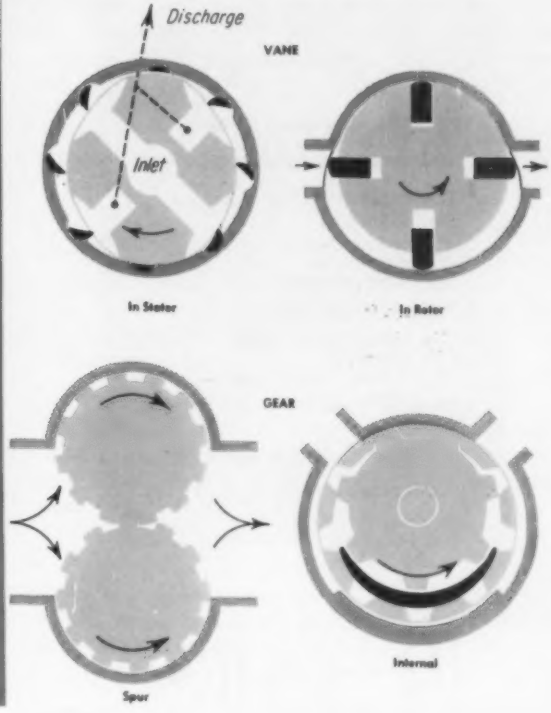
Other methods of measuring strain have been previously covered in these pages:

"Experimental Stress Analysis," Jan '55, p 182, comparison of available techniques; "Stress Equations for Strain Gage Rosettes," July '55, p 207, table of equations for calculating significant stresses from measured strains for three types of problems; "Predicting Elastic Failures," Mar '56, p 178, five requirements for a practical theory for elastic failure, and graphical methods for theories based on distortion energy and maximum normal stress; "Strain-gage Sensitivity Control," Jan '56, p 200, and Mar '56, p 196, how to apply an adjustable resistance to simplify calibration and correct for system errors.

new method predicts

CAVITATION IN POSITIVE-DISPLACEMENT PUMPS

Inlet Configuration of 4 Different Pumps



Most catalogs leave suction problems to guesswork. But a poor guess may result in a noisy pump, inadequate delivery, or damage from pitting. This article reviews the basic theory of cavitation in positive-displacement pumps; offers a consistent method of selecting pumps as well as interpreting their performance.

WARREN E WILSON
Chairman of Engineering, Harvey Mudd College, Claremont, Calif

One way to avoid cavitation is to design a pumping system that will match the suction capabilities of a particular pump. Pump manufacturers will certainly recommend that way of preventing vapor pockets behind the moving element. But the situation is usually reversed —the pump must be chosen to satisfy the system. Here is a graphical way to handle the problem.

Thorough tests on vane and gear pumps have indicated a consistent relationship between type of pump and the amount of acceleration required by the fluid inside the pumping cavity.

It is this relation that leads to the simplified equation

ABOUT THE AUTHOR

Mr. Wilson, an engineer and educator, has been President of South Dakota School of Mines and Technology, engineering consultant to numerous companies in hydraulics and related fields and, most recently, Dean of Engineering, Pratt Institute. He also organized the National Conference of Industrial Hydraulics in 1945.

These pages have carried previous articles by Mr. Wilson covering analysis and test of pumps and other hydraulic equipment: "Method of Evaluating Test Data," Oct '45, p 653; "Design Analysis of Rotary Pumps to Obtain Maximum Efficiency," Feb '46, p 138; "Analysis of Turbine Pumps," Oct '47, p 81; "Optimum Clearance in Pumps and Hydraulic Motors," Mid-Oct '55, p J6. These do not deal specifically with cavitation.

Nomenclature

- **Volume flow, cu ft/sec**
  - Q_T theoretical pump discharge, $A_P V_P$
  - Q_L loss due to cavitation
  - Q_D actual pump discharge, $Q_T - Q_L$
- **Pressure, psf](1 in. hg = 70.7 psf)**
  - P_i pump inlet
  - $P_{1,2}$ pumping cavity
  - P_A atmosphere
  - P_v vapor pressure of fluid
- **Velocity, ft/sec**
  - V_P piston, vane or tooth
  - V_i pump inlet
  - $V_{1,2}$ fluid in pumping cavity
- **Other key units**
  - A area, sq ft
  - ρ mass density, slugs/cu ft
  - g 32.2 ft/sec²
  - C cavitation factor $(V_2 - V_1)/V_P$

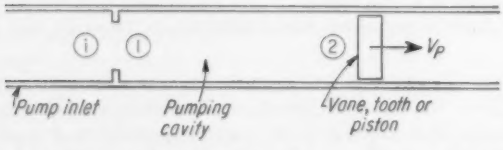
for cavitation:

$$\left(\frac{Q_L}{Q_T}\right) = 1 - \left(\frac{P_A}{\rho C V_P^2}\right)\left(\frac{P_i - P_v}{P_A}\right)$$

The terms are kept dimensionless; (Q_L/Q_T) indicates loss in flow caused by cavitation, $(P_i - P_v)/P_A$ is a measure of static pressure available at inlet to accelerate fluid up to velocity of pumping element, and $(P_A/\rho C V_P^2)$ is a coefficient that includes effects of density and acceleration. This coefficient will usually remain fairly constant at fixed speed for low values of accelerating pressure. The equation is basis for all graphs with this article. The "Probability of Cavitation" curves, for example, were plotted by letting $Q_L/Q_T = 0$ (zero cavitation) and solving for $(P_i - P_v)_c$.

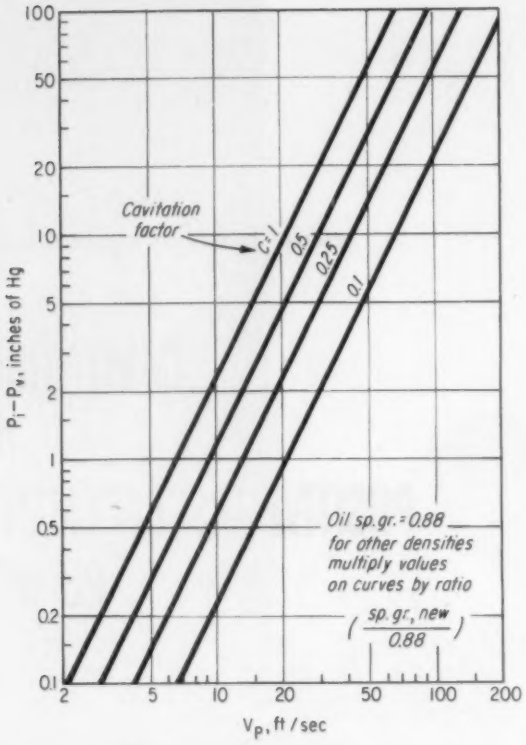
DERIVING THE EQUATION

A rigorous analysis of cavitation in an actual pump is not possible, but the idealized sketch given here of pumping elements shows important effects and provides groundwork for a workable equation.



Cavitation results if the liquid cannot keep up with the moving element, and occurs between positions 1 and 2. Fluid pressure P_1 provides the only energy available to accelerate the fluid from velocity V_1 to V_2. The value of pressure necessary is directly proportional to the pump speed V_P. The fluid velocities inside the cavity are not readily measurable, but this general equation, based on $F = Ma$, is valid:

$$(P_1 - P_2)\, A_P = \rho Q_D\, (V_2 - V_1)$$



Probability of cavitation . . .
when oil is the fluid can be quickly predicted with this graph that relates effective inlet pressure to pump velocity. Cavitation factor C is a measure of the acceleration required by fluid to reach velocity of the moving element. High values of C mean fluid is initially at standstill—requires max acceleration. Low values indicate fluid has initial velocity that helps get oil into pumping cavity.

Value of C depends on inlet design as well as pump type. Vanes-in-stator pump shown on page 47 gives pre-rotation to fluid because of centerline inlet—can have C as low as 0.25. Screw pumps may have value of 0.3, but spur gear and vanes-in-rotor pumps do no better than 0.4. Piston pumps will be poorer (0.7). Any pump can approach worst value (1.0) if inlet design is not correct.

EXAMPLE 1—hydraulic system has only 4 in. hg available at pump inlet; vapor pressure is 1 in. hg. Therefore, $P_i - P_v = 3$ in. hg. Plot for $C = 1$ shows any pump with impeller velocity less than 11 ft/sec will operate without severe cavitation. A pump that has $C = 0.5$ can be run with V_P as high as 16 ft/sec.

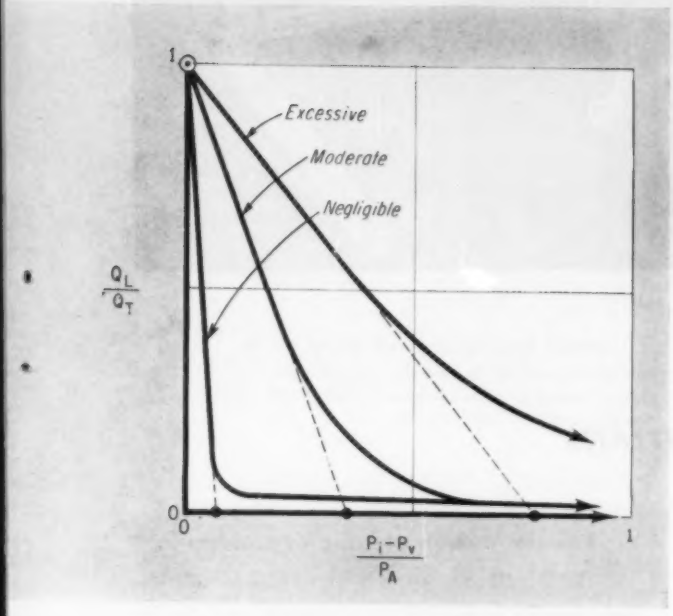
EXAMPLE 2—if pump type, speed and size are known, a velocity reading on horizontal scale can give min permissible value of $P_i - P_v$ for system on vertical scale.

Tests have shown that each pump has a characteristic value for the ratio $C = (V_2 - V_1)/V_P$. Substituting CV_P for $(V_2 - V_1)$ gives:

$$(P_1 - P_2)\, A_P = \rho Q_D C V_P$$

Let $P_2 = P_T$ (nearly correct) and $P_1 = P_i$ (valid for severe cavitation because flow is low). The equation can now be expressed:

$$Q_D = \frac{(P_i - P_v)\, A_P}{\rho C V_P}$$



Nature of cavitation . . .
is seen in these curves plotted with dimensionless parameters. Q_L/Q_T, a measure of cavitation, varies almost linearly with available positive suction pressure in region of severest cavitation. A hypothetical pump with zero cavitation corresponds to curve on extreme left, where any pressure is sufficient to give full flow, $Q_L Q_T = 0$. Actual pumps will perform in area indicated by the three other curves. Curves are for pure cavitation (effects of entrained air and slip are not included).

From the accompanying key to nomenclature, $Q_D = Q_T - Q_L$ and $Q_T = A_P V_P$. Introducing these factors and P_A gives the cavitation equation, which is a more useful tool.

CHOOSING INLET CONFIGURATION

It is not enough to specify pump type. For any pump, suction performance will be improved by guiding and accelerating the fluid before it reaches the pumping chamber. It is much more efficient to control the fluid in a smooth inlet channel than in the pumping cavity.

Some positive-displacement rotary pumps pre-rotate the fluid by having a hollow rotor shaft serve as inlet. Radial flow through special passages guides the fluid and pressurizes the pumping cavity.

Another type of rotary pump takes leakage flow from near the discharge, controls the pressure, and reduces cavitation by feeding it back to the inlet when necessary.

LIMITATIONS TO THE METHOD

Fluid that is cavitating may not flash to vapor as completely as theorized. In such cases, the pump gives better performance than predicted because back-pressure is less. Conversely, fluids with vapor pressures higher than inlet pressure can prevent pumping entirely—and pressurization or cooling of the inlet may be required.

Air or gas entrainment will increase cavitation, particularly if inlet pressure drop is great, because trapped air expands and occupies pumping space. The simplified equation assumes air has not been entrained or dissolved, and that theoretical vapor pressure of liquid is reached.

Though temperature variations will affect vapor pressure, slope of curve Q_L/Q_T vs $(P_i - P_v)/P_A$ remains the same. Any fluid system at any temperature can be examined by this method as long as there is a positive suction head.

Viscosities up to 2000 SSU do not affect performance but above that, cavitation increases. Over 20,000 SSU, it may become necessary to pressurize or heat the fluid.

Any one or all of many separate effects can produce the family of $Q_L Q_T$ vs $(P_i - P_v)/P_A$ curves shown. For example, if speed is increased but other factors remain the same, cavitation may become "excessive" instead of "moderate." But a severe inlet restriction or entrained air will give similar results. The method therefore is a guide only—careful analysis and testing will still be necessary.

WHAT ABOUT NPSH?

If desired, the new cavitation equation can be related to the older concept which defines "net positive suction head." This value (NPSH) is total inlet pressure less vapor pressure of the fluid:

$$NPSH = \frac{P_i}{\rho g} + \frac{V_i^2}{2g} - \frac{P_v}{\rho g}$$

The relationship can be seen in plot $Q_L Q_T$ vs $(P_i - P_v)/P_A$ at the intersection of straight portion of curve extended to horizontal axis. Here Q_L/Q_T is 0, and . . . .

$$\left(\frac{P_i - P_v}{P_A}\right)_0 = \left(NPSH - \frac{V_i^2}{\rho g}\right)\frac{g\rho}{P_A}.$$

EDITOR'S NOTE: Inlet cavitation and output surges of pumps are covered in a series of three articles on hydraulic-noise reduction: "Fluid Conditioning," Apr '52, p 182, explains adverse effects of dissolved, dispersed and pocketed air, and shows how to correct the problem; "Capacitive Load Chamber," Mar '52, p 135, gives theory of surges, shows how increasing line volume can change elasticity and improve both suction and discharge performance; "Piston Pump Modification," Feb '52, p 178, analyzes surge problems at discharge.

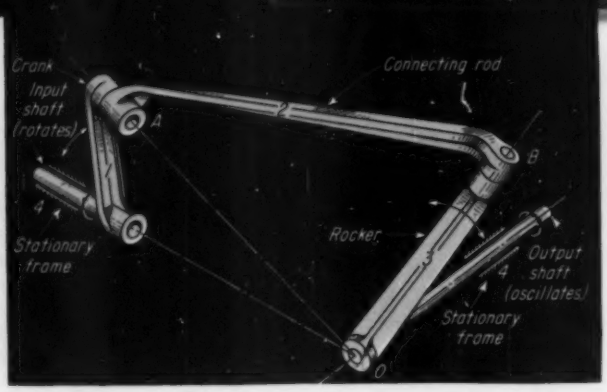
Suction lift curves for centrifugal pumps are plotted in "Centrifugal Pump Selection," Mid-Oct '57, p J17, which also covers liquids pumped, contamination, discharge pressures and performance.

General comparison of gear, vane and piston pump performance may be found in "Hydraulic Pumps," July '55, p 132, in which cavitation is covered along with viscosity, volumetric efficiency and noise.

THE ENGINEER'S BOOKSHELF

The first "Engineer's Bookshelf," published in March 1957, has been revised and will appear in the coming March 30 issue.

Listings for well over half the books in the first edition have undergone revision—for price, edition and length. More than 150 new books have been added; 35 have been dropped as out of print. Revisions in arrangement reflect experience with the first list. Watch for the revised and updated second edition on March 30.



1 Basic components . . . of space crank. One full rotation of input shaft causes one oscillation of output shaft. The shafts work at right angles to each other.

introducing the SPACE CRANK . . . *. . . a new* 3-D *mechanism*

This 3-dimensional rival to the 4-bar linkage can replace various linkages and cams in automatic machines. Design variations of such a crank are shown, also equations and curves of its displacement, velocity and acceleration characteristics.

JOHN O PREDALE and ALEXANDER B HULSE JR

Here is a new 3-dimensional mechanism that can handle many jobs in the cam and linkage field. It has the simplicity and ruggedness of a 4-bar linkage–in fact, the space crank can be classed as the 3-D version of the 4-bar linkage–but with much more versatility. With the space crank, or one of its variations, you can:

- Produce oscillatory motion from a shaft rotating at right angles to it
- Produce reciprocating motion
- Do the work of a swinging-follower cam
- Obtain toggle action
- Couple shafts whose centerlines intersect at angles up to 45°
- Get same results as with a universal of constant speed ratio.

Oscillatory Motion. The basic version of the space crank consists of four links. In Fig. 1, link 1 is the driving crank, link 2 the connecting rod; link 3, the driven rocker, link 4, the stationary member or frame. Input and output shaft axes intersect at right angles at point O; the axes of the two cylindrical pins *A* and *B* also converge at *O*.

One revolution of the driving crank comprises a cycle of motion. Beginning with the phase where link 1 is vertical, a one-half revolution of the crank causes the rocker to execute its angular stroke in one direction, and its return stroke during the next half-revolution. Turning the crank either clockwise or counterclockwise produces the same displacement pattern of the rocker. Action is completely positive as long as link 1 is made the driver.

Linear Reciprocating Motion is easily obtained by mounting an external gear segment on the driven shaft to mesh with a rack. Kinematic characteristics for this case are analogous to those of the oscillatory output.

As a Cam, the space crank can replace the more expensive swinging-follower cam system and offers operating advantages: (1) output is positively coupled to input, (2) angular-acceleration curve of output for a constant angular speed of driver is everywhere finite and continuous, (3) the first derivative of acceleration ("jerk") is also finite and continuous. These features help achieve smooth, quiet operation.

The Authors—a Meeting of Minds

This article had its inception at a meeting arranged in PRODUCT ENGINEERING's offices between an inventor and a professor.

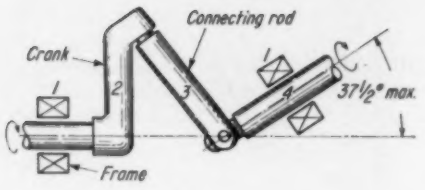
The former, Alexander B. Hulse, Jr., brought his patented space-crank idea for transmitting motion around bends. It had helped him design a new type of grass shears.

The other author was invited in to analyze the theoretical aspects for our readers. He is John O. Predale, Associate Professor in Mechanical Engineering at Newark College of Engineering. Working with partial differentials, he developed the equations and curves given here.

Example of another invention to Hulse's credit is a new differential winch (*PE*—June '55, p 184). This New Yorker is a practical man who attended the University of Wisconsin for two years, then continued on his own with correspondence courses. He lives in Staten Island, and is now with Paramount Design Co, a Brooklyn consulting firm.

Prof. Predale got his BS at Newark, his MS at Stevens Institute, and has studied for his Doctorate at Polytechnic Institute of Brooklyn. He worked in industry, and taught at Illinois Tech before returning to Newark as professor. Our readers have met him in these pages before. In "Input-output Analysis of Mechanisms" (*PE*—Mar 17 '58, p 90), he showed practicality of the principle of virtual work. He also contributed to "Coriolis Acceleration–a Force to Be Reckoned With" (*PE*—May 26 '58, p 72).

VARIATIONS OF THE SPACE CRANK



2 Coupling for intersecting shafts . . . is an "inversion" of space crank. Here, either shaft can be driver; both make full rotations. Motion is transmitted up to 37½° misalignment.

Toggle Action gives high mechanical advantage for certain phases of motion. This advantage is ratio of resisting torque (acting on output shaft) to input torque and is in turn equal to the reciprocal of the ratio of angular speed of driven rocker to angular speed of driving crank—provided friction, gravitational and inertial forces are excluded.

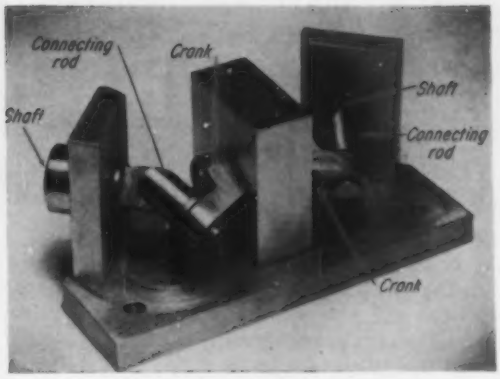
It can be verified from angular-speed curves shown later that the mechanical advantage attains very high values at the end of a cycle (or half cycle) as links 1 and 2 come into toggle (as links 1 and 2 straighten out into a common plane). Toggle action decreases as the mid-stroke position is approached. Thus the space crank can be used in mechanisms for devices such as latches, aircraft landing gears and hydraulic controls.

Coupling for Intersecting Shafts. By selecting link 1 as the stationary member, Fig. 2, an inversion of the space crank is obtained which can be employed to couple two intersecting shafts together and transmit rotary motion through bends up to 37½°. Link 4 is now the shaft coupled to link 3 by means of a clevis pin. The other shaft is keyed to link 2. Either shaft may be the driver and both make full rotations.

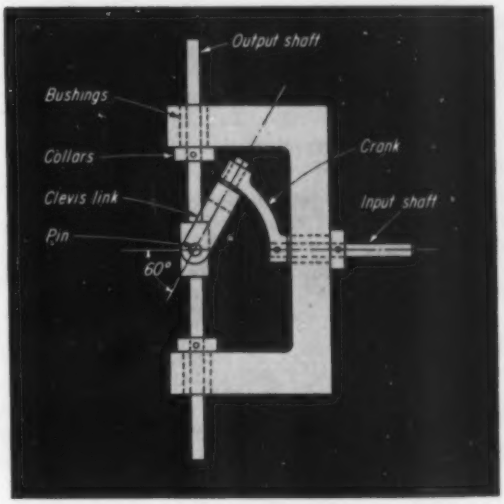
For a constant-input rotation, angular speed of the output will vary cyclically, the variation being harmonic in nature. But such cyclic motion is often needed in automatic mechanisms and one generally turns to devices such as noncircular gears, eccentrically mounted circular gears, cam mechanisms, and plane-motion linkages. The space-crank coupling is simpler and more economical.

Constant-speed-ratio Universal. To transmit power with a constant speed ratio around corners up to 75° it is only necessary to pair two inversions of the space crank in a series arrangement, Fig. 3. This gives a unique form of universal joint. Intersecting shafts with small or large angularity, as well as offset parallel shafts, can be readily accommodated. Constant-output rotation will always be obtained from constant-input rotation, providing the angle that one shaft makes with the central frame equals the angle made by the second shaft.

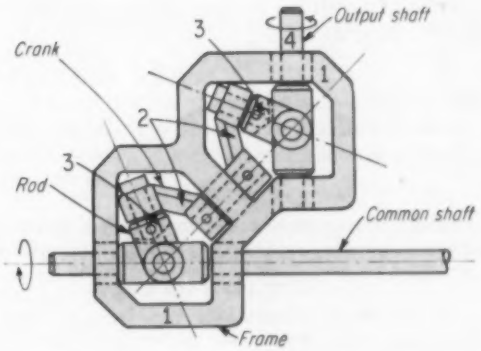
Two other variations of the space crank are shown. In Fig. 4, two support bushings provide right-angle oscillating motion; in Fig. 5, two space cranks, mounted



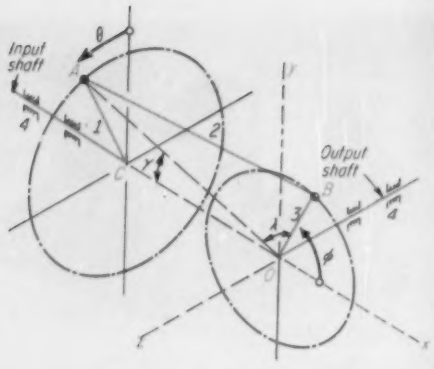
3 Constant-speed-ratio . . . universal is obtained by using two "inversions" back-to-back. Motion transmitted up to 75° misalignment.



4 Oscillating motion . . . powered at right angles. Input shaft making full rotations causes output shaft to oscillate 120°.



5 Right-angle . . . limited-stroke drive transmits exact motion pattern. A multiplicity of fittings can be operated from common shaft.



6 Schematic . . . of space crank. Angles γ and λ do not vary during rotation.

back-to-back provide a limited-stroke, right-angle drive that transmits motion faithfully.

SPACE-CRANK EQUATIONS

The schematic representation of the space crank in Fig. 6 shows ball-and-socket joints at A and B for purposes of analysis although the actual mechanisms use cylindrical pins. This does not alter motion patterns of input and output links of the actual mechanism. Another assumption is that the linkage elements are idealized rigid bodies.

Point O is taken as the origin of a right-handed, 3-dimensional, "Cartesian" coordinate system orientated such that the x and z axes coincide with the axes of input and output shafts, respectively. Angular positions of driving crank θ and driven rocker ϕ are considered positive when measured in the directions indicated.

Two important design parameters are cone angle γ of the driving crank and central angle λ of the connecting-rod. When the linkage is in operation, triangles OBA and OAC move as rigid planes; hence for a given space crank, angles γ and λ do not change.

Displacement Equations

Points A and B can be expressed in terms of θ and ϕ; thus for point A:

$$x_A = -(OC),\ y_A = (CA)\cos\theta,\ z_A = (CA)\sin\theta;$$

and for point B:

$$x_B = (OB)\cos\phi,\ y_B = (OB)\sin\phi,\ z_B = 0.$$

Length of connecting link 2 is:

$$(AB)^2 = (x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2 \quad (1)$$

Substituting previous values for points A and B gives:

$$(AB)^2 = (OB)^2 + (CA)^2 + (OC)^2 + 2(OB)(OC)\cos\phi - 2(OB)(CA)\cos\theta\sin\phi \quad (2)$$

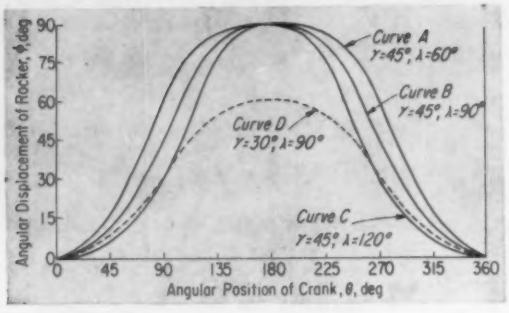
Two additional relationships from triangles OBA and OAC are:

$$(AB)^2 = (OA)^2 + (OB)^2 - 2(OA)(OB)\cos\lambda$$

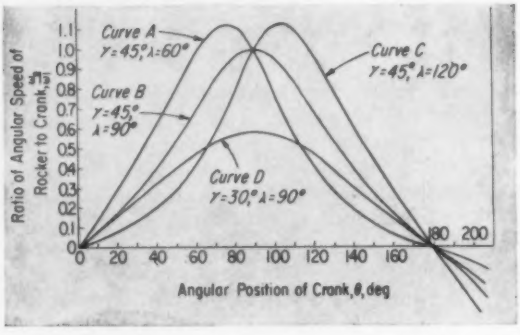
and

$$(OA)^2 = (OC)^2 + (CA)^2$$

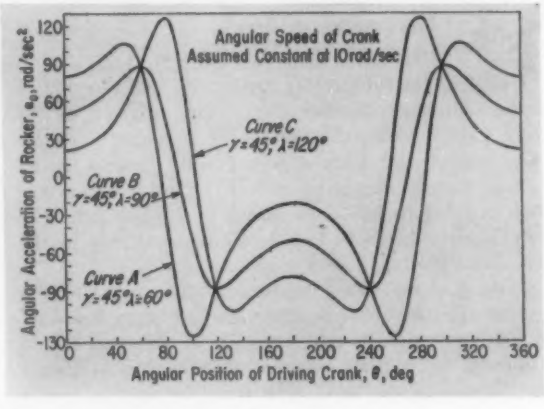
MOTION CHARACTERISTICS OF THE SPACE CRANK


Angular Displacement of Rocker, φ, deg
Angular Position of Crank, θ, deg
Curve A γ=45°, λ=60°
Curve B γ=45°, λ=90°
Curve D γ=30°, λ=90°
Curve C γ=45°, λ=120°

7 Displacement curves


Ratio of Angular Speed of Rocker to Crank, dφ/dθ
Angular Position of Crank, θ, deg
Curve A γ=45°, λ=60°
Curve B γ=45°, λ=90°
Curve C γ=45°, λ=120°
Curve D γ=30°, λ=90°

8 Velocity curves


Angular Acceleration of Rocker, α_φ, rad/sec²
Angular Position of Driving Crank, θ, deg
Angular Speed of Crank Assumed Constant at 10rad/sec
Curve C γ=45°, λ=120°
Curve B γ=45°, λ=90°
Curve A γ=45°, λ=60°

9 Acceleration curves

Utilizing these values in Eq (2) gives

$$\cos\phi = \tan\gamma\cos\theta\sin\phi - \frac{\cos\lambda}{\cos\gamma} \quad (3)$$

Because angles γ and λ remain fixed for a given mechanism, constant a and b can be defined such that $a = \tan\gamma$, and $b = \cos\lambda/\cos\gamma$. Eq (3) can then be written as

$$\cos\phi = a\cos\theta\sin\phi - b \quad (4)$$

This equation relates the positions of input and output shafts, θ and ϕ. It is shown plotted in Fig. 7 for various values of parameters γ and λ. For comparison

purposes, the curves were shifted vertically to start from the same datum point, $\phi = 0$. Note that total angular displacement of the rocker ϕ remains the same for any one value of γ: increasing λ only narrows shape of the curve (however, this affects the velocity and acceleration characteristics).

Reducing the value of γ will reduce the total ϕ. In general, total $\phi = 2\gamma$. Angle λ must always be chosen greater than γ to avoid jamming.

When $\lambda = 90°$, as with curves *B* and *D*, Eq (4) reduces to this simple form:

$$\cot \phi = a \cos \theta \qquad (5)$$

This equation, unlike Eq (4), can be solved directly.

All displacement curves are continuous and symmetrical with respect to the axis of ordinates. This means the same position pattern is obtained for the rocker regardless of whether continuous rotation of the driving crank is clockwise or counterclockwise.

Speed and Acceleration Equations

Angular speed of the driven rocker, $\omega_o = d\phi/dt$, for an arbitrary input angular speed, $\omega_i = d\theta/dt$, is established by differentiating Eq (4) with respect to time. A second differentiation will give the angular acceleration of the rocker, $\alpha_o = d^2\phi/dt^2$, and crank $\alpha_i = d^2\theta/dt^2$.

To simplify differentiation, functional notation is employed; therefore from Eq (4):

$$f(\theta, \phi) = \cos \phi - a \cos \theta \sin \phi + b = 0$$

and

$$\theta = \theta(t)$$

Here $\theta(t)$ symbolizes the known but arbitrary position function of time for the driving crank.

Following the rules of differentiation of implicit and composite functions, it can be shown that the general formulas for $d\phi/dt$ and $d^2\phi/dt^2$ are as follows:

$$\frac{d\phi}{dt} = -\frac{\dfrac{\partial f}{\partial \theta}}{\dfrac{\partial f}{\partial \phi}} \frac{d\theta}{dt} \qquad \left(\frac{\partial f}{\partial \phi} \neq 0\right) \qquad (6)$$

$$\frac{d^2\phi}{dt^2} =$$

$$-\frac{\dfrac{\partial^2 f}{\partial \theta^2}\left(\dfrac{d\theta}{dt}\right)^2 + \dfrac{\partial f}{\partial \theta}\dfrac{d^2\theta}{dt^2} + \dfrac{2\partial^2 f}{\partial \theta \partial \phi}\dfrac{d\theta}{dt}\dfrac{d\phi}{dt} + \dfrac{\partial^2 f}{\partial \phi^2}\left(\dfrac{d\phi}{dt}\right)^2}{\dfrac{\partial f}{\partial \phi}} \qquad (7)$$

The various partial derivatives of $f(\theta, \phi)$ appearing in the foregoing fromulas are:

$$\frac{\partial f}{\partial \theta} = a \sin \theta \sin \phi$$

$$\frac{\partial^2 f}{\partial \theta^2} = a \cos \theta \sin \phi$$

$$\frac{\partial f}{\partial \phi} = -(a \cos \theta \cos \phi + \sin \phi)$$

$$\frac{\partial^2 f}{d\phi^2} = a \cos \theta \sin \phi - \cos \phi$$

$$\frac{\partial^2 f}{\partial \theta \partial \phi} = \frac{\partial^2 f}{\partial \phi \partial \theta} = a \sin \theta \cos \phi$$

Substituting into Eq (6) and (7) gives the speed equation:

$$\omega_o = \omega_i \left(\frac{a \sin \theta}{1 + a \cos \theta \cot \phi}\right) \qquad (8)$$

and the acceleration equation

$$\alpha_o = \frac{(\omega_i^2 + \omega_o^2)\, a \cos \theta + \omega_o \cot \phi\, (2a\, \omega_i \sin \theta - \omega_o) + a\alpha_i \sin \theta}{1 + a \cos \theta \cot \phi} \qquad (9)$$

As no assumption was made regarding the nature of the angular speed of the driving crank, Eq (8) and (9) are applicable for ω_i constant or variable.

When ω_i is constant, the term containing α_i in Eq (9) will vanish, but Eq (8) remains unchanged.

Performance curves derived from Eq (8) are plotted in Fig. 8. Output speed is expressed in dimensionless form as speed ratio of rocker to crank. It is evident the curves are continuous and symmetrical with respect to the origin (which makes it antisymmetrical with respect to the axis of ordinates). Thus with exception of algebraic sign, the angular-speed ratio pattern is independent of the direction of input rotation.

For the undistorted curves *B* and *D*, Eq (8) assumes the more simplified form:

$$\frac{\omega_o}{\omega_i} = \frac{\sin \theta}{\dfrac{1}{a} + a \cos^2 \theta}$$

Peak values for these curves are reached when the driven rocker assumes its mid-stroke position. This does not hold true, however, for curves A and C in which the central angle λ is not equal to 90°.

It is seen that the angular-speed range increases with increasing values of parameter γ. On the other hand, parameter λ does not appear to exert much of an influence except in producing distortion of a curve for values other than 90°.

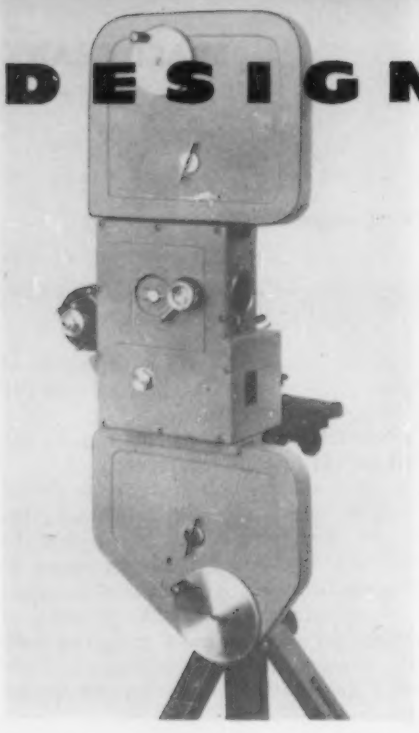
Acceleration performance is summarized in Fig. 9 for an arbitrary value of constant angular-speed input of 10 radians per sec. No discontinuities appear in the curves, and the derivative of these curves, or "jerk," is finite and continuous for all values of θ. Favorable dynamic effects, and smooth and quiet operation, can be expected when the pulse function is everywhere finite and continuous.

Of the three curves plotted, curve B has the smallest range of acceleration. This range may be decreased by employing smaller values of γ.

Also, the acceleration function is independent of the rotational direction of the driving crank. Thus the acceleration curves are symmetrical with respect to the axis of ordinates.

REPRINT of this article can be obtained for your reference file by checking E69 on one of the Reader service cards bound in this issue. For further reprints available see "Current Reprints" listing this issue on page 94.

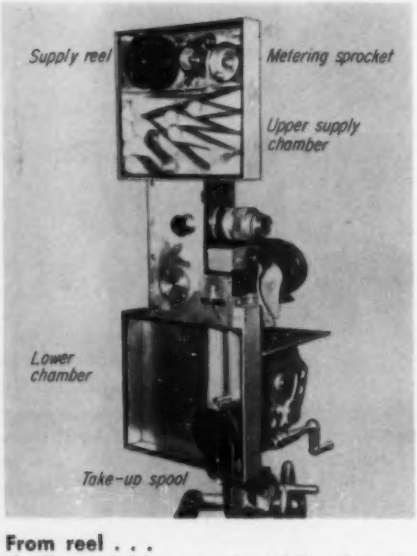
EDITOR'S NOTE: For readers who want to know more about 4-bar linkages, here are latest concepts on putting them to work: "Graphical Synthesis of Four-bar Linkages," Feb 2 '59, p. 40. "Roberts' Law Helps You Find Alternate Four-bar Linkages," Oct 27 '58, p 54.



Fast Camera Feeds Film from Hopper

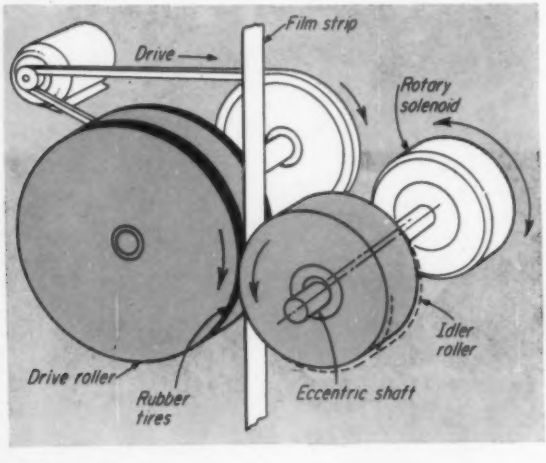
The roll film is metered into a supply chamber where it's held in loosely looped fashion before shooting. This lets camera reach speed of 1600 frames/sec in 2 to 3 milliseconds—without stretching or tearing the film.

The idea for this high-speed industrial camera grew out of needs by bird watchers. Using 16mm or 35mm film, the camera can operate at 200, 400, 800 and 1600 frames/sec. Metering allows loop-storage of 1 to 40 ft of film for each shooting sequence. Stroboscope light gives intense flashes, lasting 1 to 3 microseconds, at rates up to 6000/sec. Synchronizing pulses, from a pickup that scans film perforations, are fed to control unit—it gives a single flash of illumination when each frame is registered precisely in the film gate. Camera was designed by L C Eichner Instruments, Clifton, NJ; is fabricated for E I du pont de Nemours & Co, Wilmington, Del.



From reel . . .
the film needed for a sequence is fed to the upper supply chamber by the metering sprocket and arranges itself in completely random fashion into a number of loops or festoons. The chamber can hold 30 ft (1200 frames) of 16mm film. Because of the loose looping only the film at the film gate and in the first half loop are accelerated at any instant. As the drive mechanism pulls film through chute and gate, new areas of film are progressively accelerated until chamber supply is almost depleted.

Limiting the duration of each run prevents film from being drawn directly from the supply reel—with damage to film and camera. Below the drive-rolls the film is dumped into the lower chamber, again piling up in random fashion; after each run it's wound onto the take-up spool.

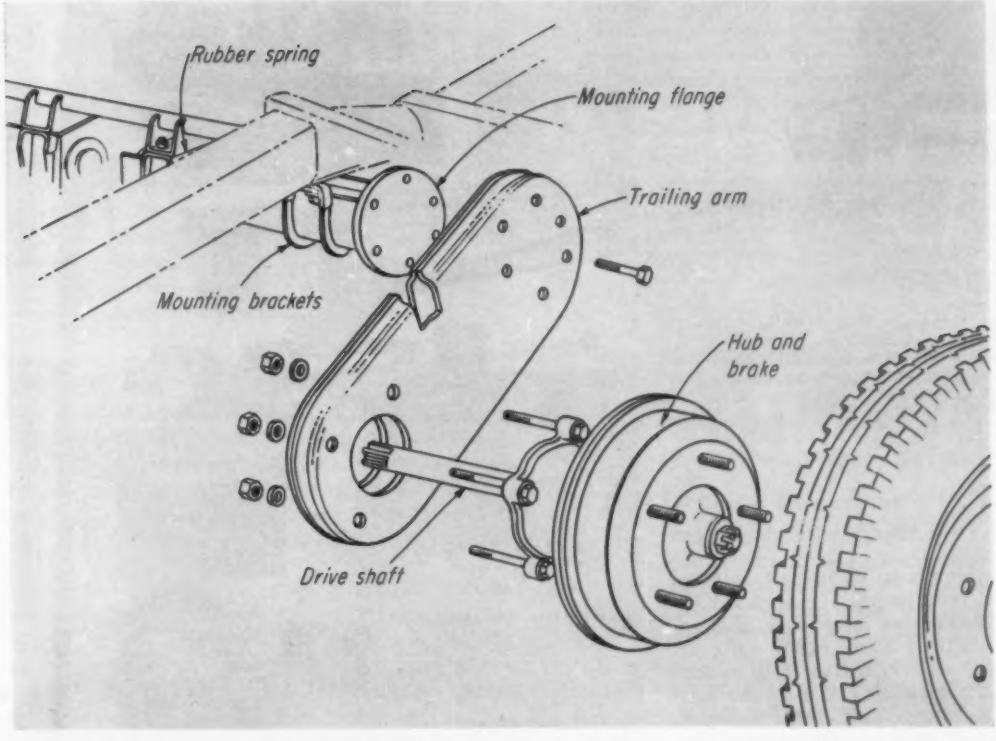


Wring rollers . . .
bring film up to speed rapidly. The constantly rotating rollers normally have a peripheral clearance of from 0.010 in. The idler roller, mounted on an eccentric shaft, is driven by a pair of narrow rubber tires on the edges of the larger roller. Energizing a rotary solenoid mounted on the eccentric shaft causes the shaft to rotate, bringing the two rolls tightly together on the film. Acceleration of the film to the peripheral velocity of the rollers occurs within the first ¼ in. of film motion.

Independent, trailing-arm suspension on all wheels, plus rubber springs, helps this utility truck over the bumps. Steel pressings and stampings are used for all suspension members.

The utility vehicle seats three on bench-type driver seat and six in the rear on wheel wells. Design also allows mounting a winch, power take-off or mechanical tire pump. Two 4-cyl engines are available: a 62-hp gasoline unit, or 55-hp diesel engine using fuel injection. Designed for farm jobs or other rough terrain, the Gipsy is produced by Austin Motor Company Ltd, Longbridge, Birmingham, England.

Truck Has Rubber Knees



Rubber springs . . .
are used on all four wheels. The suspension units, one at the front and two at the rear, consist of a steel center tube to the outside of which rubber is bonded. The rubber is also bonded to the lower half of a two-piece outer tube. The upper half of the outer tube is pressed into position during assembly, placing the rubber in compression, and spotwelded to the lower half. Flanges on the center tube provide a mounting surface for the pressed-steel trailing arms.

All suspension deflection are absorbed by the torsional loading of the rubber. No maintenance or adjustment is required during the life of the vehicle.

PRODUCT DESIGNS

CRANE STRIPS FOR TRAVEL

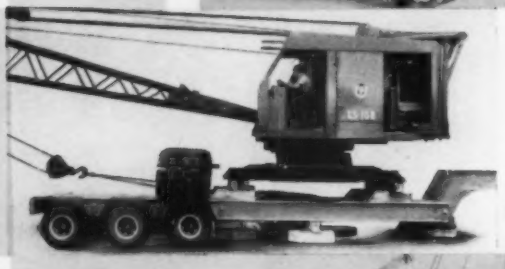
Here's a crawler crane that disassembles itself and loads the parts. Removable tracks reduce width and weight to comply with highway regulations.

Easily converted to back-hoe, clamshell or dragline operations, the standard crawler crane can lift its 160-ft-long boom and jib from ground to operating positions unassisted. Crane model LS-108 has 40-ton capacity; produced by Link-Belt Speeder Corp, Cedar Rapids, Iowa.

1

2

3



4

5

6

Six steps . . .

prepare crane for transportation on standard low-body trailer. Counterweight is lowered (1) to ground by powered gantry. Operator then swings crane, picks up and loads counterweight . . . Crane mounts trailer (2) and blocking is placed under cross axles. Bolts holding cross axles to side-frame are removed and outer traction shaft is uncoupled . . . First crawler side-frame assembly is pulled from cross axles (3) and placed on ground . . . Second side-frame is removed (4) and placed on ground. Crawler assemblies need not be taken apart because sprockets and drive chain are integral with side frames . . . Detached tracks (5) can be loaded on separate transporter or rear of low-bed trailer . . . Ready to travel (6), trailer weighs 32,000 lb, is 8 ft wide. Entire operation takes less than two hours.

No muss, no fuss when such components go into assemblies. Just peel off the backing sheet—and hand pressure will do the bonding because . . .

these parts carry their own ADHESIVES

R C LILLIE, *Applications Engineer, Angier Adhesives Dept, Interchemical Corp, Cambridge, Mass.*

The advantage of pressure-sensitive adhesives is easy to see. They can come right with the part—you just strip off a backing sheet and the built-in adhesive is exposed, waiting only for moderate hand pressure to give it a firm grip on another part in the assembly.

This design solution is an appealing one—particularly with low strength requirements and when service temperatures aren't too high. There's no messing with the adhesives themselves, no handling and storage problems, and special equipment is seldom required. Despite these advantages, pressure-sensitive specifications must be drawn right—for there are places where they do not apply. Here is a briefing on this latest adhesive-bonding technique.

What Are They?

Pressure-sensitive adhesives are permanently tacky, solvent-free films which a light pressure will stick avidly to most any substrate—metal, plastic, elastomers, felt, paper, for example. Most are thermoplastic, limiting them to room-temperature applications. However, softening rate depends on formulation, and some special grades will resist prolonged exposure up to 500 F.

Like other adhesives, the pressure-sensitives are designed to take a tight grip on both the part being mounted and the surface to which it is affixed. But the pressure-type adhesive is applied by the manufacturer of the part, or—in certain cases—by the end-user of the part. Hence the protective release paper that the user must strip off at assembly. Compatibility of this backing sheet with the specific pressure-sensitive formulation is important: It must release consistently over the expected shelf life of the part. This is usually determined by an accelerated aging test.

Chemical compatibility between paper and adhesive, or between base material and adhesive, is also important. The release paper may contaminate the adhesive—either by softening that reduces creep and shear resistance, or by absorbing the resins that give it permanent tack.

Base materials present special problems. Most pressure-sensitives are susceptible to oils that tend to migrate to the adhesive, changing its tack characteristics. Many plastics, vinyls for example, use softening agents—and subsequent heating during operation of the part may cause these agents to migrate. Then the adhesive itself softens—weakening the joint.

On porous carrier surfaces, primers or tie-coats are often included to minimize the penetration or wetting into the surface which will drop the dry film thickness below specification. Some plastics, like vinyls, may need tie-coats too—for chemical anchoring of the pressure-sensitive. Extensive testing on both release paper and base material to be coated will insure uniform stable coating. This is usually the function of the adhesive converter who applies the adhesive to the carrier material.

Film Thickness Important

Next comes the important specification of film thickness. Some adhesive will be absorbed by the base material. The remaining thickness can be adjusted to give different adhesive and cohesive strengths. Normally, from 0.0005 to 0.003 in. is the desirable range: Below this range, the chance increases of no contact during installation because of local surface irregularities, and shear strength may suffer. Above this range, adhesion improves —especially on porous surfaces where the adhesive will conform to surface irregularities—but creep resistance usually suffers.

Pressure and Temperature

The bonding usually needs only firm pressure with the hand, followed by a smoothing action to remove bubbles

Adhesive Performance Compared

Property	Type of Adhesive		
	Pressure	Contact	Structural
Peel strength, lb/in. width	0.5–4	25–50	10–20
Tensile strength, psi	25–40	60–200	200–15000
Shear strength, psi	30–50	50–600	1500–5000

and wrinkles. More pressure will, of course, mechanically increase adhesion by driving the adhesive into interstices in the surface to which the part is applied. However, hand pressure—plus aging at room temperature for 24 hr—is required for max wettability in most applications.

Initial rate of adhesion requires about 70 F to 100 F for max wettability. Although higher bonding temperatures increase the tentacles of adhesion, they also tend to lower cohesive strength of the adhesive itself while hot—especially as its thermoplastic temperature is approached—thus temporarily lowering shear strength and tensile strength of the bond. Some pressure sensitives of high molecular weight, when used on porous-base materials, are heated to as high as 200 F for better flow characteristics. At low service temperatures, 50 F to 0 F, specially formulated pressure-sensitives must be specified, as rate of adhesion to substrate drops sharply. The 24-hr aging period at room temperature is a must, however, for developing full strength—regardless of adhesive or temperature.

Where They Come From

The basic elastomers employed in pressure-sensitives include natural rubber, polyisobutylene, butadiene, styrene, acrylonitrile, polyacrylates, silicones, polyvinyl ethers. They, in turn, are modified by tackifying resins like the rosin esters, polyterpenes, and phenolics, which combine with the polymerics to provide a wide range of properties.

Viscosity ranges between 3,000 and 60,000 centipoises (light to medium paste) with solid content varying between 30% and 50%. Most pressure-sensitives come in solvent systems employing aromatic and aliphatic hydrocarbon blends. Aqueous-pressure sensitives are also available.

With these adhesives and their primers or tie-coats, special equipment and techniques are required. Reverse roll, knife coater, and gravure equipment are favored for both primers and adhesive. Drying is accelerated with multiple rewind equipment, and insertion facilities are required for the paper.

Recent developments in solvent-free, film-form pressure-sensitive adhesives in narrow and wide widths, allow parts to be pressure-sensitized with simple combining or laminating equipment. The adhesive film is cast on a carrying sheet which acts in the final assembly as the release paper. This allows tinkering with prototype parts or starting with low-quantity production.

How They Perform

Such adhesives are not a cure-all, as the comparative strength figures in the accompanying table show. Their permanently tacky state requires a solvent-free film, hence they do not have the same surface-conforming action on irregular surfaces as the resin and elastomer cements. These have a wetting action on porous surfaces and an attacking action on plastic and rubber surfaces not achievable with pressure-sensitives.

In effect, joint strength is sacrificed for ease of handling—and the joint must be designed accordingly. Currently, the industry is being asked for higher strength pressure-sensitives, as well as formulations with high heat resistance. Both conventional and thermosetting types are being studied—with special emphasis on resistance to weather, ultraviolet and ozone.

Design Considerations

There are six other points peculiar to pressure-sensitive adhesives, and designing parts for them.

- Curved surfaces, concave or convex, require base material that is flexible, with good dimensional stability and little inherent springback. This rules out some laminates that tend to curl after installation.
- Embossed patterns, either on the pressure-sensitized part or the other surface, diminish the useful area of adhesive contact. Area remaining should thus be checked to see if it meets minimum requirements. Similarly, very rough adherend surfaces should be smoothed.
- Large areas of adhesion raise problems of degree of tack. If the pressure-sensitive is too tacky, it won't form when the part is smoothed in place—and wrinkles or air pockets result. Answer is a lower-tack adhesive, or more pieces to cover the same area.
- Edges should be protected from peel by recessing or by turning the edge away at normal handling points. Recessing hides the edge, too, when the pressure-sensitized part is bulky.
- Butt joints are feasible only when the adhesive-carrying part is known to be dimensionally stable. Otherwise, lap seams must be used—with grooves for offsetting one lap where appearance is critical.
- Creep is the biggest enemy of permanency here, so determine dead loads accurately and check creep resistance of the adhesive—preferably under simulated service conditions—before specifying.

EDITOR'S NOTE: Other recent articles dealing with adhesives, and designing joints for them, include:

"Stresses in Adhesive Joints," July 7 '58, p 64, analyzes 6 basic joints; shows how to calculate their stress concentrations.

"Sandwich Panel Adhesives," May 26 '58, p 56, compares the 14 most widely specified adhesive types. Though published as one section of a 3-part series on sandwich panel materials, this article contains an unusually complete rundown on industrial adhesives.

"Which Adhesive for What," March 17 '58, p 66, tells what a good structural adhesive should do, compares basic types in chart form, and gives a simplified shopping list.

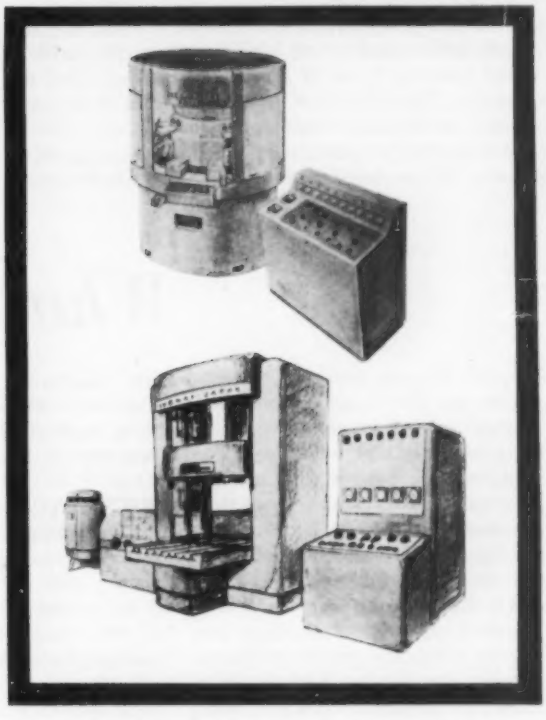
"Single-component Epoxy Adhesive," May '57, p 104, covers strength and curing data for paste adhesive requiring no hardener.

"Adhesives for High-temperature Applications," Mid-Oct '58, p G25, evaluates several types of epoxy resin adhesives under different loadings.

ELECTROMACHINING
speeds its attack . . .

Basic Japanese spark machine . . .
has novel impulse generator that ups rough-cutting speed 40 times over US and European models—thus promising to add electrical-discharge machining to US production lines.

It not only will shape the materials that other processes cannot, but a new Japanese machine now leads the trend to faster cutting speeds with improved surface finish. This means design can now solve those "impossible" jobs on a production basis. Here's the latest on Japanese equipment, along with a review of what the electromachining processes can offer and how they work.



Signs of promise . . .
are these preliminary Japanese designs for multiple-head production machines. Upper sketch shows single-station, multiple-head machine for high-speed production of small parts like diesel injector nozzles. Large machine in lower sketch has multiple heads for simultaneous cutting of different areas in large forging and stamping dies. Impulse generator for high removal rates is at far left.

H L KEE, *Assistant Editor*

CAUTION: Don't underrate those Japanese high-speed electrical-discharge machines. They're all they have been cracked up to be, according to R. E. Van Deventer, executive vice-president of Alloy Engineering & Casting Co. His appraisal is based on first-hand inspection of the equipment in Japan last month.

In an exclusive interview with PRODUCT ENGINEERING, Van Deventer concedes American industry has been interested, but with a "show-me" attitude. The visitor from Champaign, Ill., was shown. Those machines developed at Ikegai Iron Works by Dr. K. Inoue feature an impulse generator that does what's claimed—it helps the spark machine rough-cut steel at removal rates up to 60 gm/min.

Van Deventer puts it this way: "These machines can remove metal—in rough, medium or finish cuts—at rates equal to or better than present mechanical methods, and with as good or better surface finish. Compared with other electrical-discharge equipment, Inoue's innovations have more than doubled cutting speed for all desired surface finishes. For roughest cuts, this improvement factor jumps to 40 times."

Such performance, illustrated in the curves (next page) from Ikegai, makes electrical-discharge machining a natural when cutting dies for large parts like auto roofs, refrigerator panels and the like; and preliminary design of multiple-head machines is proceeding—sketches for some of the Ikegai ideas are shown above. Final designs will depend on jobs generated here, says Van Deventer. He's consultant on this evaluation for General Alloys Co of Boston, which will distribute the machines with Japax-America Corp, Seattle.

"Although the Japax process holds greatest appeal to tool and die people like ourselves," the Alloy Engineering executive explains, "US companies playing with it so far have been smitten by the way it can bail the

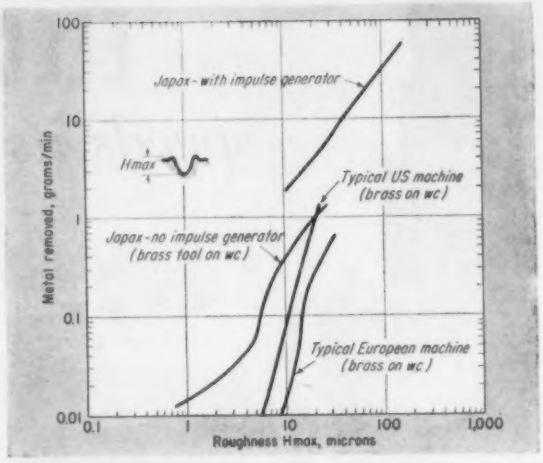
design engineer out of a hole. He can now go ahead with that 'impossible' job because these high cutting speeds make his design economically feasible."

Cutting stainless and aluminum honeycomb is another area where the process will have impact on design. Clean, square cuts can be made, insuring perfect contact with facings for bonding or brazing. On this, Van Deventer would say only that experimental cores have been produced in Japan for evaluation by the American aircraft industry, and that preliminary designs are underway for adapting the basic head to a setup for cutting sandwich.

Based on his experience with electrochemical machining, Van Deventer is confident that Japax-ing will team up with the older process on the same equipment. "The same power sources can be used," he points out, "and only the circuitry has to be shifted. Electrical-discharge machining will supply precision the designer wants, and electrochemical machining will give the smoothing finish cut desired on so many parts."

First design innovation by Dr. Inoue is a unique power supply and control circuit, used on the small machines, which provides sparks of shorter duration at higher frequencies. This "Gandhi" or passive-resistance circuit is Inoue's outstanding contribution.

Arc control is maintained by a delicate servo system sensing voltage characteristics of the gap. Inoue's system



Forty times as fast . . .
as present US and European equipment, Japax electrical discharge machine with special impulse generator can remove metal at rates up to 60 gm per min. for rough cutting. Standard unit, D103, also cuts faster and finishes to much smoother surfaces. Higher speeds make spark machining a production tool for parts of unusual configuration. Above, microinch rms ≅ 8.33 H_{max}.

What electromachining

Speed accounts for the growing interest in electromachining. These methods range from electrolytic grinding to wearing a metal down with electronic erosion. They are broadening their usefulness because some of them can now work faster. At the same time, the harder materials specified nowadays for increased strength have slowed down the more standard machining processes. Result is that design now can economically specify electromachining processes that were previously limited to specialties—such as working the ultrahard metals for tools and dies.

Electromachining offers other advantages too:

- Tool-and-die tolerances . . . as low as ±0.0001 in. in certain shapes.
- Smooth surface finish . . . as low as 7 microin., compared with 6 microin. for best hand-lapped finishes.
- Low distortion . . . parts can be finished after heat-treatment.
- Absence of burrs . . . this means less hand finishing.

Properly applied, methods increase the scope of design where heat- and corrosion-resistant alloys, carbides, ceramics, hardened steel, and other hard-to-machine materials are necessary. The processes basically use electrical discharge, electrolytic erosion, ultrasonic abrasion—or variations of these methods. Each has specific advantages . . . within its own limits.

ELECTROLYTIC PROCESS

Best known of the methods, electrolytic "grinding" uses principles of plating—that is, electricity transports metal ions in solution. The movement of these charges between electrodes is caused by a potential difference, usually less than 25 volts. Current flows from the work, which is positively charged, and through electrolyte to a negatively charged electrode. This carries metal, in ion form, from the work. In one machine a disk revolves at high speed so fresh electrolyte is pumped between work and disk to reduce polarization and maintain current density. The electrolyte also carries off the eaten-away metal.

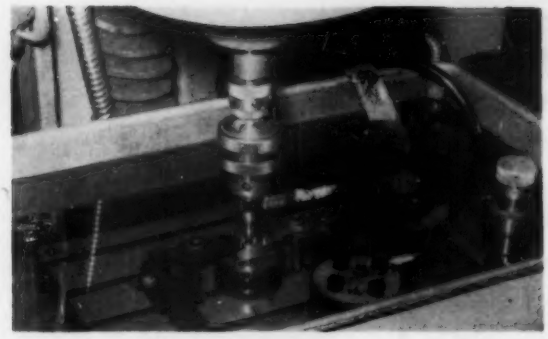
The electrolytic method will "grind" any conductive material that can be conventionally ground. It has these advantages over conventional grinding: savings in expensive abrasives such as diamond bort; minimum wear on the cathode; no grinding stresses; extremely good finishes independent of the cutting rate. Specific accuracy, finishes, and stock-removal rates depend largely on the machine and the particular application.

A typical unit which can be connected to any good standard grinder is widely used for face grinding, surface grinding, and cutter grinding. In operation, it maintains maximum voltage and current for most efficient removal of stock, but reduces the voltage before sparking begins or before finish will be damaged by arcing. Result is the high stock-removal rates run about six times greater than those obtained with conventional grinding methods. Diamond wear is reduced to 10 or 20% and total grinding costs usually run ¼ or less the cost of conventional grinding.

ELECTRICAL-DISCHARGE PROCESSSES

In contrast with the electrolytic method, electrical-discharge processes are essentially electromechanical. They work either by the electro-spark method or the spark-erosion method. Best known are the widely used tap-disintegrators.

In the electro-spark method, stock is removed by passing pulsed dc of the spark-discharge type between the



Magnetron anode is cut . . .
by spark machining. Copper stock is immersed in dielectric fluid—circulated to flush particles out of intricate waveguide shape shown below. Tool is machined from brass bar stock. Hole is cut by slowly lowering tool as high-frequency spark cuts the metal.

uses a mechanical servo for coarse control, with an ultrasensitive magnetic servo for finest control. This feature, along with the power supply advantages, contributes to the higher removal rates.

For these speedy rates, Inoue has designed a radically new impulse generator. By discarding conventional commutator rings and brushes, it gets around the mechanical problems of current designs. Though exact details are not specified, lower frequencies and longer duration sparks are used, and process is under full control. Thus material removed is not deposited on the tool or redeposited on the work.

The close control over spark discharge has several benefits. Range of surface finishes, for example, has been widened. It is now as low as 7 microin. rms, as against best hand-lapped finishes of 6 microin. The tolerance concept is changed too. Says Van Deventer: "The difference in size between tool (electrode) and work is predictable, constant and exact—thus precision of the part depends on precision of the tool. Size difference varies, from 0.0003 in. at lowest removal rates to 0.006 in. at highest rates. Accuracy is within ±0.001 in. and below 0.0005 in. on finish cuts, and experimentation with the machine in the US has shown that part after part can be produced without shifting from whatever part of the tolerance range the first part hit." ■

can offer . . .

anodic work and a cathodic tool. Frequencies range from 10 to 1000 kc and current from a few hundred to 20,000 amps. Working voltages run from 40 to 400. Both electrodes are immersed in the liquid dielectric—which is pumped through the spark gap to flush away particles dislodged from the tool and work.

For each cycle, the voltage across a capacitor builds up until the dielectric in the gap breaks down to produce an ionized path. Breakdown voltage is held by automatic gap regulation.

On the anode, material is in tension and because forces of the electric field exceed rupture strength, particles are torn off and driven through the dielectric toward the cathode. At the cathode, the material is in compression so particles do not have the same tendency to dislodge. Therefore, material removal here at the tool is much slower than at the work.

Practicality restricts the minimum gap length to about 0.001 in. For safe operating voltages, maximum gap length is around 0.020 in. Local variations in gap give a rough surface finish. For fine finishes, this effect and others can be minimized by using low voltages and capacitances.

Because the form cut in the work follows shape of the tool, any transverse section can be made, including such irregular shapes as splines, gears, and other toothed sections. If the tool is a bolt or stud and is rotated while simultaneously advanced, it can tap an internal thread in any conductive material, no matter how hard. Multiple cutting of complex shapes in carbide or other hard materials can be done by stacking them. Cost of producing these irregular shapes is much lower than with conventional methods.

The spark-erosion method can be used for tool sharpening, surfacing, forming, piercing, die making, or polishing. Here, as with other electromachining processes, spark erosion makes the work anodic and the tool cathodic. The arc between tool and work is surrounded by a dielectric fluid. It also acts as coolant; by confining the heat, it prevents damage to adjacent metal. And by carrying away positively charged particles before they can reach the tool, it slows wear. Coolant is supplied from the outside or through a hollow cathode.

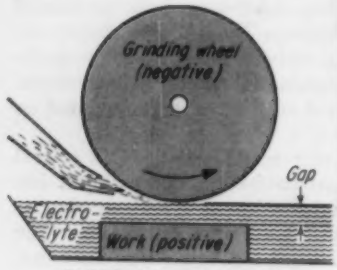
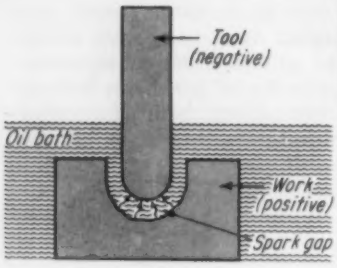
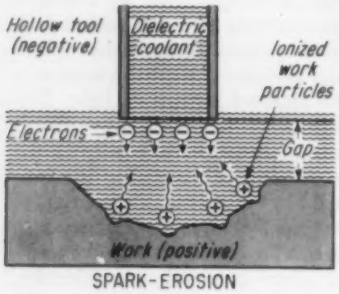
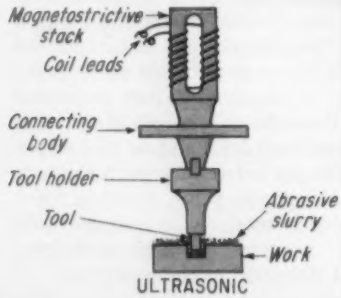
Operation consists of a series of discharges—20,000 to several million per second—between the tool and work. To create one of these discharges, a voltage is built up, and electrons accumulate on the tool surface until they break through the surface barrier and race toward the work at a speed approaching that of light. Discharge voltage is controlled by the gap between tool and work (usually 0.0015 to 0.002 in.). This spacing is maintained by a servomechanism that moves the tool as work progresses.

When the electrons strike the workpiece they bombard its molecules, causing a small portion of the surface to reach heat of vaporization. The electrons also knock electrons from the vapor atoms, leaving them with a net positive charge. These positive particles are attracted to the negative tool. While moving, they are cooled by the dielectric coolant (there is no ionized path here) and are washed out of the gap before they reach the tool. At the proper point, power is interrupted so most of the heat goes into the removed particles—minimizing heat distortion of the workpiece.

ULTRASONIC PROCESS

The ultrasonic process does not use electric current directly for stock removal, but it belongs with these spe-

4 Ways to Machine "THE UNMACHINABLE"

Process	Applications	Advantages	Limitations
 ELECTROLYTIC GRINDING	Conductive materials Face and surface grinding Large areas—flat or shallow curves in one plane For delicate and thin work	No residual stresses Surface finish—5 microin. Stock removal 6 times faster than conventional grinding Low wheel wear—10 to 20% of normal grinding	Gap (0.0008 in.) must be automatically controlled to avoid arcing Not suited to small surfaces and small blind holes
 ELECTRO-SPARK	Conductive materials Small, deep holes or recesses Holes with irregular shapes	Gives square, hex or any irregular shapes Tolerances—±0.0005 in. Fast stock removal Surface finish—26 microin.	Gap regulation necessary
 SPARK-EROSION	Conductive materials Multiple holes in thin stock Close hole-spacing Contour-machining flat stock	No distortion in hole shape—tolerance, ±0.0001 in. Holes as close as 0.005 in. No distortion in web between holes Negligible taper—0.0001 in./in.	Gap spacing (0.0001 in.) is critical
 ULTRASONIC	Hard, brittle materials Conductive materials or insulators	Does not alter material surface Tolerances—±0.0005 in. Finish better than 10 microin. Worn tools can be used for roughing	Deep holes have taper Cannot cut soft, tough materials

cial machining processes because it also cuts "unmachinable" materials. Unlike the previous methods, it grinds nonmetals and insulators as well as conductive materials and metals.

One model can cut 0.012-in. holes, or slots of that width, in the hardest material. The more brittle the material, the faster the cut, and the better the dimensional accuracy. Thus, dies of hardened tool steel can be machined after heat-treating.

Stock is removed by an abrasive driven at high frequency and low-amplitude vibration. The tool, usually steel or brass, is vibrated from 16,000 to 29,000 cps through an amplitude of a few thousandths of an inch. The abrasive, boron carbide, is suspended in water between work and tool. Fineness of the abrasive determines dimensional accuracies and the surface finish—for example, 280-grit boron carbide produces a 25-micron finish.

An oscillator delivers ac to a magnetostrictive transducer which converts the high-frequency electricity to mechanical vibrations. The vibrations are amplified through a conical connecting body and a tool holder to an amplitude sufficient for cutting. Result is the tool vibrates about 0.003 in. These vibrations cause cavitation which drives the abrasive grit into the work surface and does the cutting.

Tool shapes and sizes are determined by the hole to be made. Generally, tool holders are designed for each particular job and are dependent on the material, the size, type and shape of hole, and the cutting rate.

Threaded holes are tapped after making a hole of tap-drill size. The tool is simply a threaded stud brazed to its holder. Work is held in a threaded adapter with the same lead as the screw or bolt. This adapter is rotated so that the work moves upward on a spiral as the tool feeds into the work, thus giving internal threads identical to those on the tool.

EDITOR'S NOTE: For information on additional processes that offer unusual shapes for parts and concepts in design, see:

"Chemical Milling," Feb 3 '58, p 51—design data on etching large-scale production parts that other methods cannot handle.

"One Temperature for Successive Brazes," Dec 8 '58, p 84—describes multiple brazing process that allows fabrication of complex parts without loss of high-temperature properties.

"Plasma-arc Plating," Dec 8 '58, p 104—shows how 20,000-F temperatures can shape tungsten production parts.

Rubber Bonded-to-Metal Parts

Precision know-how, care, and special bonding techniques assure you of parts that will reduce assembly costs, improve product operation and simplify design.

Just send your problems—your blueprints to Precision for solution. Our engineering staff will be glad to make recommendations and quote to your requirements.

Specify Precision — first in quality

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

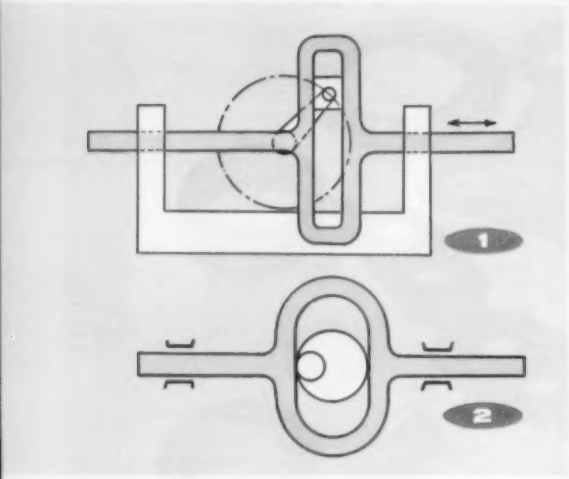
Dept. 6, Oakridge Drive, Dayton 7, Ohio

Canadian plant at: Ste. Thèrése de Blainville, Québec

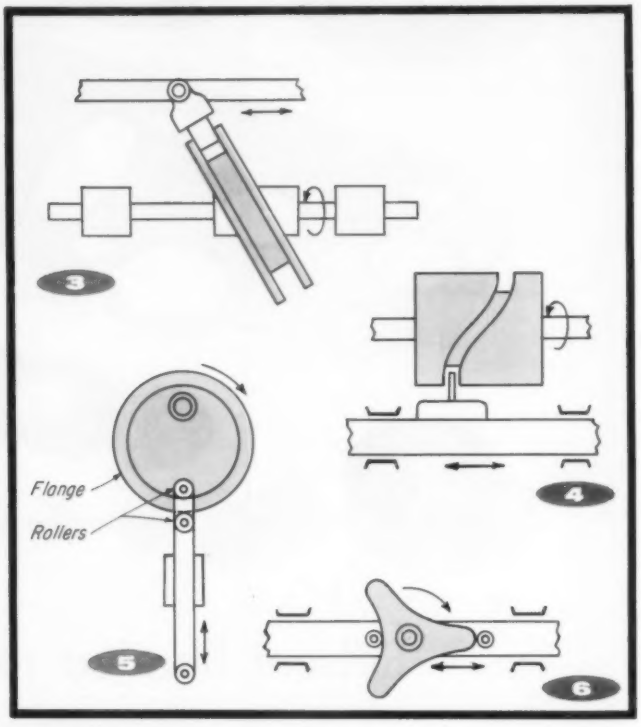
20 CONVERTING MECHANISMS FOR

Basic arrangements and adjustable crank-throws, plus some special cases for dwell periods and intermittent motion.

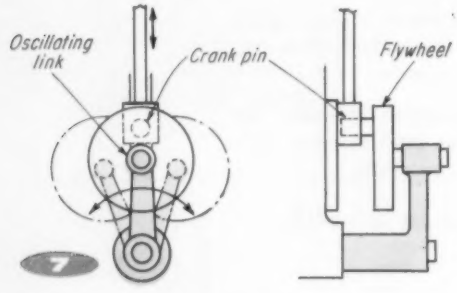
BASIC ARRANGEMENTS



Scotch-yoke type . . .
mechanisms here are two examples of many similar arrangements for converting a driving, rotary motion to a reciprocating one. In most cases a flywheel is necessary if the driving force is also reciprocating, and a way must be provided to restart the rotary member if it stops at top-dead-center. Motion is simple harmonic.

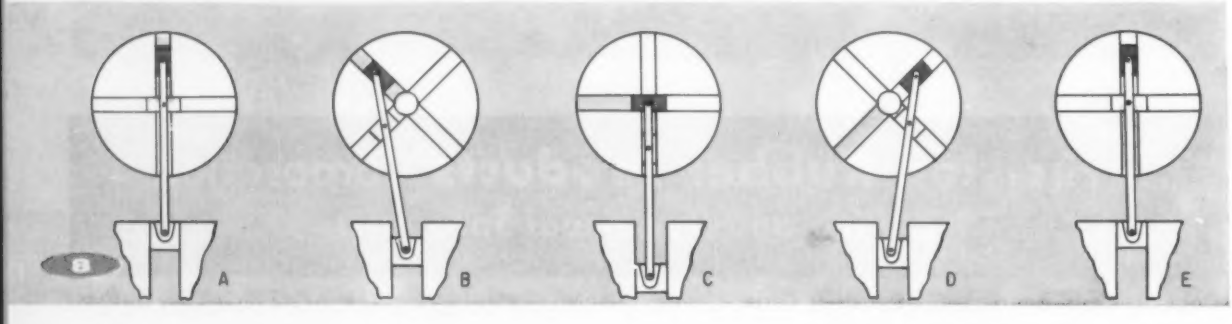


Cam-type drives . . .▲
and their sliding followers generally convert rotary to linear motion.



◀Flywheel oscillates . . .
as it drives, therefore the crankpin moves in a straight line.

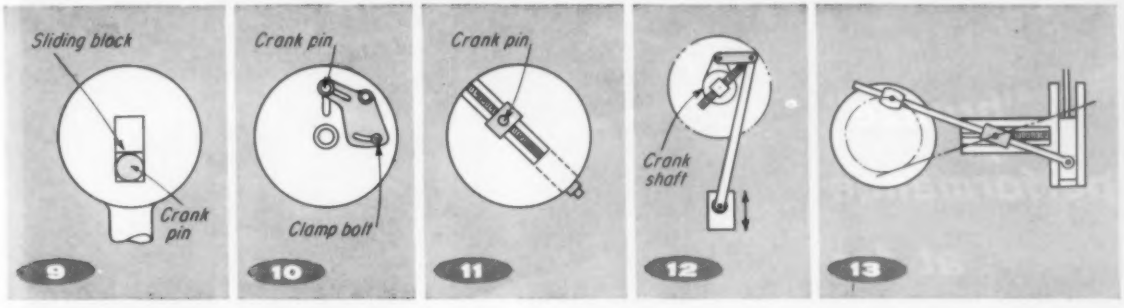
Trammel crank-gear . . .▼
gives one complete forward-and-return crank-stroke (A through E) for each half revolution of the drive wheel. Motion approximates simple harmonic.



ROTARY—LINEAR MOTION

FEDERICO STRASSER, *Mankowitz & Strasser Ltd, Santiago, Chile*

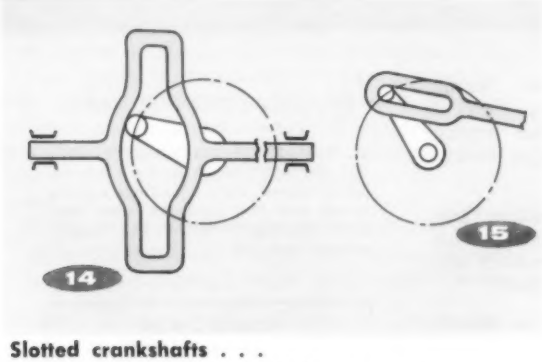
ADJUSTABLE CRANK-THROWS



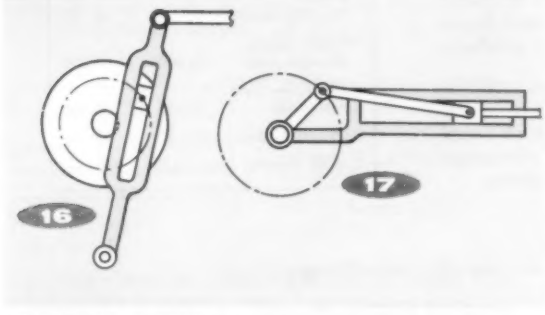
Sliding blocks, plates and . . .
adjusting screws allow crankpin position to be changed to suit velocity-force or assembly-adjustment requirements.

Adjustable fulcrum (13) is useful variation when adjustable-crankpin method happens to be impracticable.

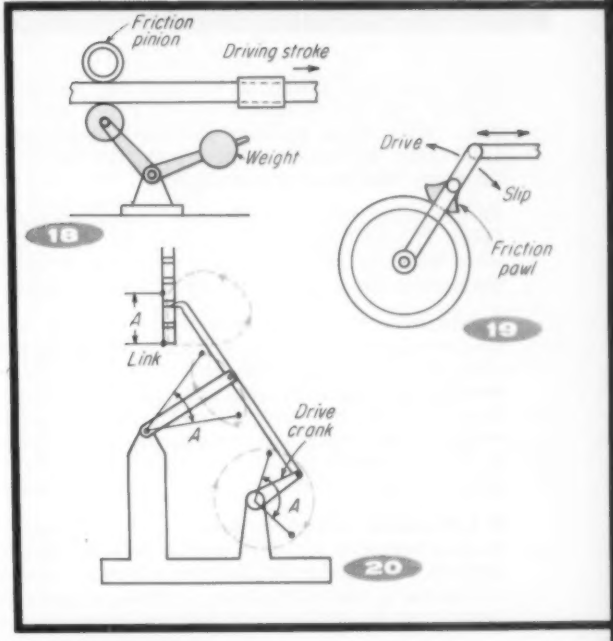
SPECIAL CASES



Slotted crankshafts . . .
cause a dwell period at the end of each stroke.



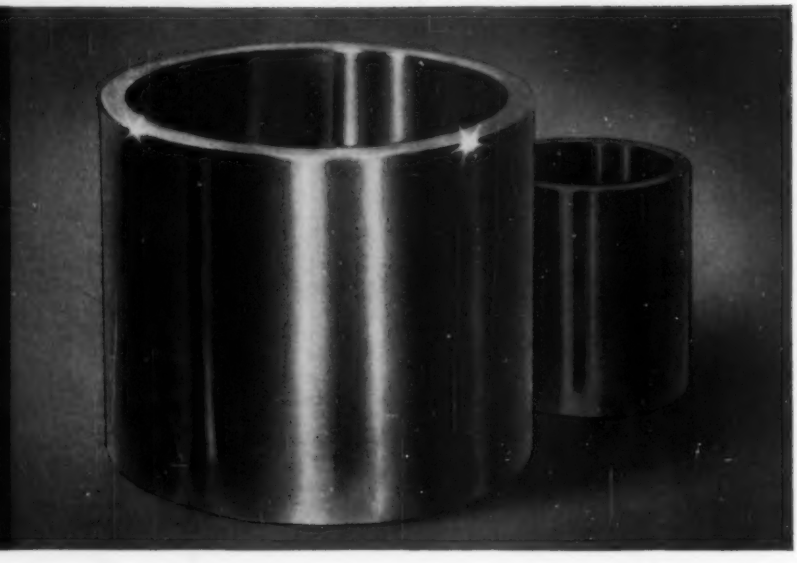
Quick-return motion . . .
is given by these arrangements. Shaping machine is common example of application for drive shown in (16).



Intermittent-motion . . .
devices here rely on friction to grip, in a wedging action, and translate reciprocating linear drive motion to rotation. Silent ratchet (19) gives immediate response, is ideal when high-precision adjustment in one direction only is desired. Film feed (20) is interesting example of how rotary and reciprocating movements, combined by a link, perform special function; linear and angular dimension *A* is limit of straight-line feed movement.

introducing NEW IRON OILITE 212 BEARINGS

"bronze" performance at far less cost



The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

Performance-proved in life tests and on actual products, Iron Oilite 212 bearings have a service life equal to porous bronze when used for products where corrosion is not a problem and mechanical strength requirements are within tolerable limits.

A high oil content — approximately 20% by volume — assures adequate lubrication for the lifetime of many end products. In addition, a unique built-in service factor gives Iron Oilite 212 bearings extraordinary protection against temporary overloads. They perform best when carrying medium to heavy loads at relatively low speeds and readily equal the performance of bronze at the high speeds required by home appliances, fractional horsepower motors, power tools, light machinery and other products.

It's another Amplex first . . . a typical example of how Amplex serves a growing number of original equipment manufacturers with "better quality at lowest cost". Use Amplex's extensive research and engineering facilities to your own advantage. Savings can be impressive if you require bearings in volume.

free sample

of IRON OILITE 212 Bearing 1" ID x 1¼" OD x 1" Length and full information on request. Consult the Oilite engineer in your area. Find him in the Yellow Pages under "bearings" or write direct to Amplex. Address Dept. A-3

COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

* REGISTERED TRADEMARK
ONLY CHRYSLER MAKES OILITE

SINCE 1929 — A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

AMPLEX DIVISION
CHRYSLER CORPORATION, DETROIT 31, MICHIGAN
SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

THE 6 TYPES of CORROSION . . . a preventive guide

To prevent trouble—know the cause. Though there still are puzzles concerning just how corrosion works, the destruction can be traced to six basic beginnings. The author describes each, along with examples and preventives.

PETER C NOY, *Production Engineer*
Canadian General Electric Co Ltd, Barrie, Ontario

The problem of corrosion is simplified here by breaking it down into six basic causes and showing what design can do to minimize or overcome each kind of trouble.

Such a listing is necessarily artificial because corrosion is often puzzling—even to experts. All the physical and chemical phenomena involved are not yet fully understood. Moreover, the corrosive attack is often the end result of a combination of causes. However, focusing on individual causes can help combat even the more complicated challenges that face design in this field.

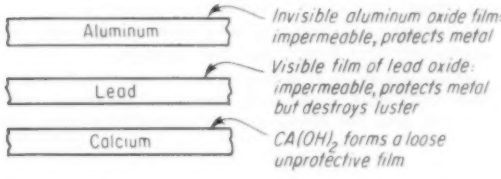
Corrosion resistance usually depends on some form of protective film (oxide coating, electroplating, paint, etc). But mechanical action—such as air bubbles, scraping, flexing, cavitation and moving liquid—can destroy this film and expose the base metal to the corrosive environment. When this happens corrosion sometimes occurs at a dramatically swift rate, e.g. aluminum scratched under mercury will oxidize visibly at the scratch when exposed to the air.

Three basic recommendations are:

1. Have the design examined by a corrosion expert.
2. Test the product exhaustively. Here, keep as close to service conditions as possible, and include the most severe conditions.
3. Watch out for environmental surprises (for example, hot coffee dissolves nickel plate a thousand times faster than will drinking water).

THE MECHANISMS OF CORROSION

1 Direct Attack. The most important example here is formation of oxide films when metals are exposed to air. These films are usually protective, as with aluminum and lead. Some metals, however, act differently—for example, those that reluctantly oxidize in dry air but readily form unprotective hydroxides in moist air. (Calcium, melting at 1436 F, and harder than tin, would be a useful manufacturing metal if not for this destructive affinity for water.) So:


Aluminum
Invisible aluminum oxide film: impermeable, protects metal
Lead
Visible film of lead oxide: impermeable, protects metal but destroys luster
Calcium
$CA(OH)_2$ forms a loose unprotective film

Select materials that form stable films when exposed to service conditions.

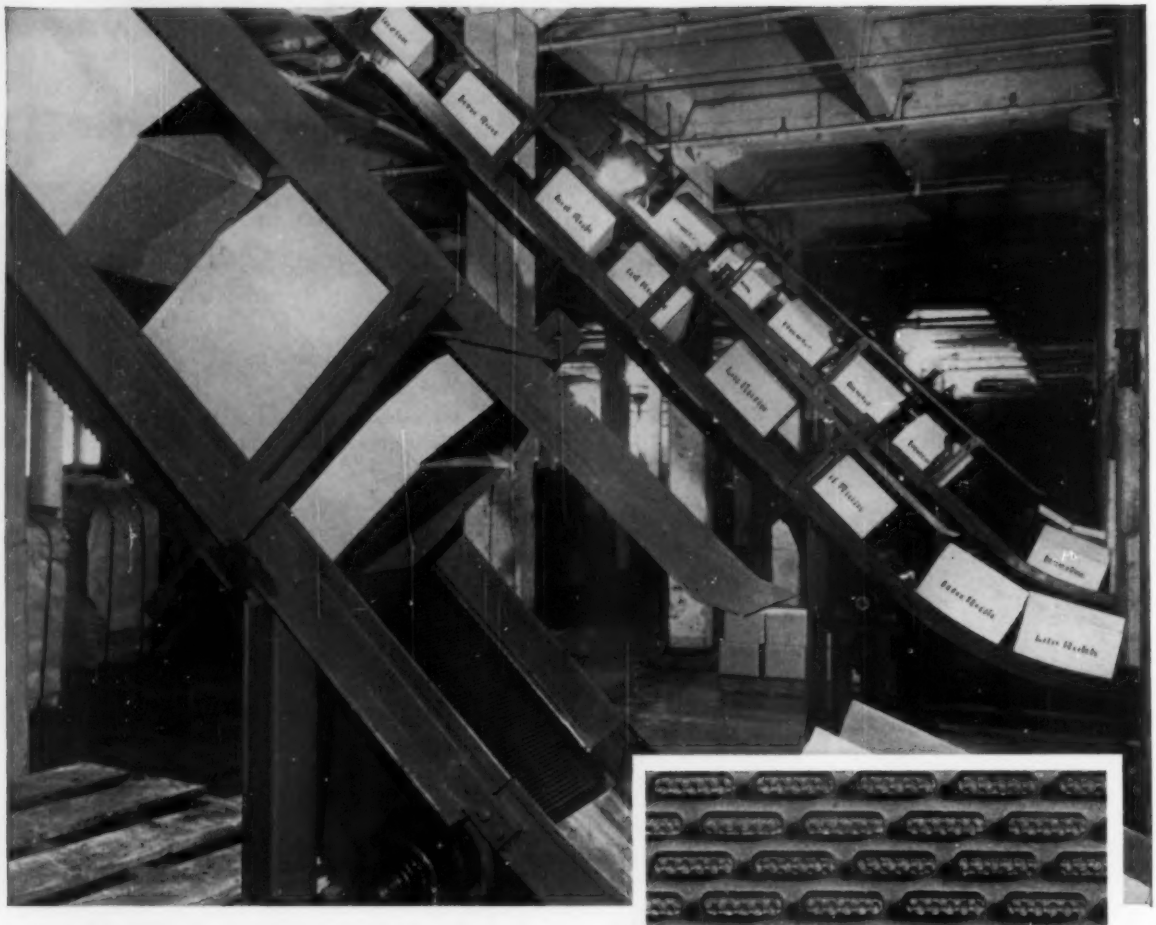
Foodstuffs (vinegar, salt, etc.) can also cause direct attack.

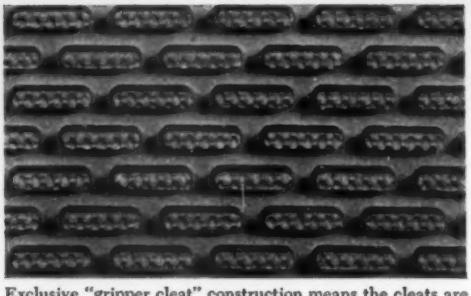
2 Complex Attack. In some media, metals that ordinarily form protective films are prevented from doing so because of an intervening reaction at the surface.

Thus iron immersed in water that contains no impurities but a very small amount of oxygen will first form ferrous hydroxide at the surface; only then will insoluble ferric oxide start forming—but at a distance from the surface, say, 1 mm.

(CONTINUED ON PAGE 69)

US RUBBER **STEEPGRADE CONVEYOR BELTING**





Whatever became of Gravity?

Exclusive "gripper cleat" construction means the cleats are *not* attached or cut in; they are *molded*—a true and integral part of the belt—and cannot be torn off by heavy boxes.

It's hard to believe that these cartons are not nailed down to the U. S. SteepGrade Belts, so steep is the angle of descent. The scene is the American Can Company's plant in Baltimore, Md., and these light, smooth-finished cartons are being carried at an angle of 45 degrees—*with no slippage.* The sharp angle is necessary because existing floor beams and walls limit the space.

Before the installation of U. S. SteepGrade Belts (there are 10 in all) the cartons went down chutes. This often caused pile-ups at the bottom, with spilled cans, broken cartons and lost tempers. But SteepGrade now offers controlled descent, with cartons evenly spaced. Exclusive "gripper cleat" construction holds the cartons firmly—even at steep, gravity-defying angles—thereby saving valuable floor space, conveyor length and belt footage.

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and the finest quality industrial rubber products.

US RUBBER **Mechanical Goods Division**

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

THE 6 TYPES of CORROSION
. . . a preventive guide (cont.)

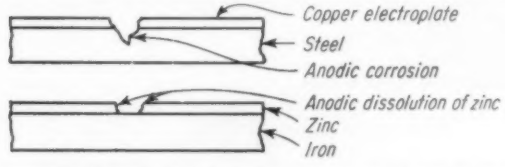
If, however, the supply of oxygen is increased, the protective oxide will be formed at the surface, thus slowing the attack.

Remember that natural waters vary greatly in content of such dissolved gases as oxygen and carbon dioxide. Life-testing is the safest and often the only answer.

3 Galvanic Action. Dissimilar metals, when in contact in a medium capable of carrying a current, will form a cell in which one metal becomes a cathode and the other an anode. The anode will dissolve (the rate depending largely on where the metals stand in the electromotive series) and the cathode will usually be protected.

The best example here is in electroplating, where metals come in intimate contact with each other.

Copper-plated steel, for instance, is poor protection against

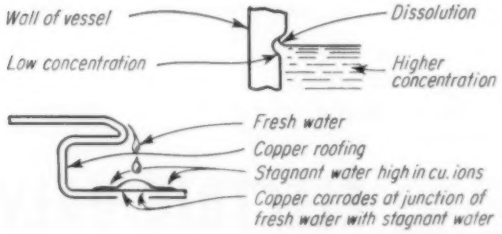


corrosion because steel is anodic to copper. Pores in the electroplate become cells that promote the dissolution of the steel.

On the other hand, zinc is anodic to iron, and zinc electroplate or galvanized coating will dissolve while the base metal is protected. Cathodic action is at base of the pores. This is a small area in comparison with the anodic area and insures long protection of the steel.

Consult the electromotive series to select those metals for contact that are close to each other in potential. When specifying electroplate, the coating should be anodic; if this is impractical, it should be specified as nonporous.

4 Concentration Cell. If for any reason the metal-ion concentration of the corroding medium drops when in contact with a metal, then ions of metal will be forced into solution to maintain a balance. This condition exists at the surface



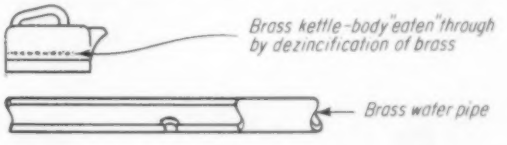
of a liquid, accounting for corrosion at solution lines. Circulation of the liquid, and cracks or crevices, lodgement of organic matter such as slime, or even stagnation beneath loose films of corrosion products, would lead to this type of corrosion. Illustration shows corrosion of copper roofing due to dripping of relatively low-concentration electrolyte (rain water in industrial area).

Where the medium is a moving one, avoid causes of irregular circulation (lap joints, crevices, etc.)

Condensation streams should be watched where condensate runs back into a vessel, causing differences in concentration.

5 Dezincification. Brass is subject to this kind of corrosion. In very soft waters with high concentrations of carbon dioxide the zinc constituent of brass dissolves out, leaving a spongy mass of copper.

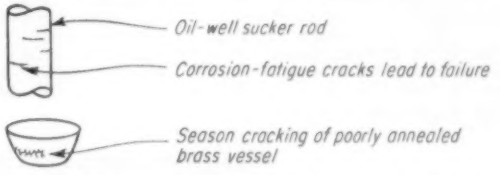
Brass water pipes can be deceptive. Sometimes a small



area or plug of porous copper (dezincified brass) in the wall of the pipe causes a slow leak, which subsequent liming may stop. Any disturbance or increase in pressure, however, may cause sudden failure.

Where soft water conditions occur, keep brass low in zinc—less than 15%.

6 Fatigue and Stress Corrosion. Stressed metal, when in a corrosive medium, is subject to harm greater than from the sum of the corrosion and stress effects. If the stress is cyclic, the mechanism is called *corrosion fatigue*; if static, it is *stress corrosion*. Machine parts operating in corrosive places, engine blocks, boiler parts are all prone to such corrosion. The best example of stress corrosion is shown in



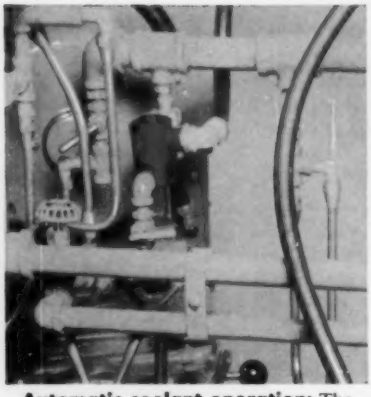
brass having internal stress. In corrosive media, including most natural waters, deep-drawn brass vessels will crack right through in a pattern called season cracking—it resembles the cracks in seasoned wood.

Anneal all machine parts to be used in corrosive media.

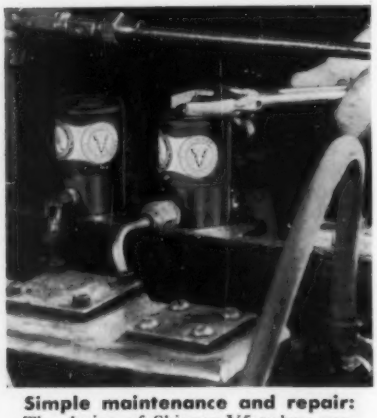
Fatigue corrosion can be avoided by proper coatings on the part—if a corrosion-resistant electroplate will remain bonded under cyclic stress, you need only design to resist the fatigue effect itself.

Why Skinner V5 solenoid valves are solving so many control problems

Application: The Leland-Gifford nine-unit hydraulic drilling machine used for drilling crankshafts uses two-way Skinner V5 valves to control the flow of coolant at each operating station of the fixture.

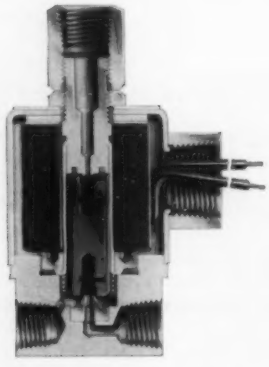


Automatic coolant operation: The Skinner V5 2-way normally closed valves are wired so that at the start of the drilling operation the valves are energized causing coolant to flow before the drill starts its drilling pass. When the cycle is complete the drill retracts, the valves are de-energized and the flow of coolant is halted.



Simple maintenance and repair: The design of Skinner V5 valves permits hand disassembly for cleaning without removal of the valve from the line. Coils, housings, plungers, sleeves are interchangeable and easily replaced.

Skinner stainless steel V5 valves are offered in two- and three-way construction, normally open, normally closed, directional control, multi-directional, quick exhaust. Orifices: 1/32″ to 3/8″; NPT ports: 1/8″, 1/4″, and 3/8″; pressure ratings: to 3000 psi. Explosionproof models UL approved for both Class I, Group D and Class II, Groups F and G are available.



Engineered to highest UL standards: Body and internal parts of *frequently copied* V5 valve are stainless steel and, thus, corrosion-resistant. Durable, compressible inserts of soft synthetic materials insure bubbletight operation. Orifice seats have radius with well-rounded contact area and high finish for long insert life.

100% tested. Prior to shipment, every V5 valve is tested for both internal and external leakage under full pressure conditions with modern, sensitive detecting equipment. In these laboratory tests Skinner V5 valves regularly get over 20-million cycles without leakage. And these results are constantly proving out in service.

Skinner solenoid valves are distributed nationally.

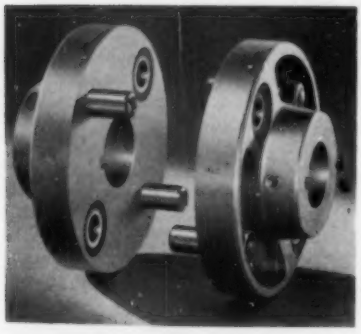
For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 453

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

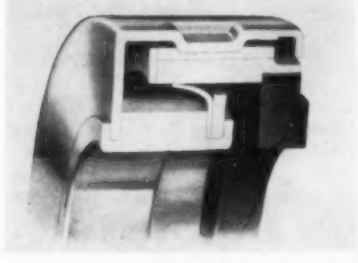
SIGNIFICANT COMPONENTS MATERIALS PROCESSES



Flexible couplings . . .

for use on direct-driven machinery where torque is not excessive in relation to shaft diameter are made with 1¼, 1¾, 2¼ and 2¾-in. max bore, respectively, with standard square keys. Four steel studs and rubber-cushioned sleeve bearings provide resilient drive. Said to require no lubrication. Cast semisteel flanges are machined on periphery and face to simplify checking alignment with feeler gage or straight edge. **Ajax Flexible Coupling Co Inc, Westfield, NY.**

Circle 1, Reader Service Card



All-metal shaft seal . . .

functions at temperatures from −65 to 850 F, or more, limited only by metallurgical progress in high-temperature alloy steels. All components, except seal face, are made of various high-temperature alloy steels, each with optimum properties necessary to its function. Said to function at temperatures, pressures and speeds in excess of capabilities of currently used organic materials. Hydraulic balance produces optimum sealing under static and dynamic conditions. Seals can be washed in any solvent, because internal parts will not be damaged. Delivery time is approximately 12 wk. **Gits Bros Mfg Co, 1866 S Kilbourn Ave, Chicago 23.**

Circle 2, Reader Service Card

Self-locking coupling nut . . .

for hydraulic lines, adaptable to flared or flareless methods of tube sealing, resist loosening under severe vibration even when not fully seated. Said to be unaffected by oils. Reusable more than 15 times without impairment of locking properties. Allows at least one full turn for free engagement of male threads before locking action takes place. Fasteners are offered in cadmium-plated steel for applications to 550 F and in silver-plated stainless steel for temperatures to 800 F. Each series contains nine sizes, ¼ to 1½ in. dia. Priced from 13¢ to $3; delivery, 4 to 6 wk. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 3, Reader Service Card

High-pressure valve line . . .

for hydraulic service to 3000 psi is said to meet JIC requirements. Available in five actions: moved manually to either end position; moved manually to IN position and spring-offset to OUT position; moved manually to OUT position and spring-offset to IN position; spring centered, or ball detent where valve piston is held in either end position by detent. Valve is subplate-mounted and manually controlled by lever. Large unrestricted passages permit high flow capacity. For example, 1-in. size is rated at 28.2 gpm at 15 fps. Piston has long sealing surfaces; spool is shock-resistant by metering fluid with scalloped design. Offered in seven basic design in sizes from ¼ to 1½ in. Prices range from $54 to $245. Approximate delivery, stock to 10 days. **Rivett, Brighton 35, Boston.**

Circle 4, Reader Service Card

Electroluminescence in color . . .

includes green, greenish yellow, deep yellow, deep blue and white. Red is produced by means of supplementary luminescent material. Experimental panels are 2 in. sq but can be made in larger sizes to meet individual requirements. Panels are operated on alternating voltage, 120 or 240 v, depending upon type. Experimental 2x2-in. panels available from stock in limited quantities. Plain panels are $10 each; numeral panels, $10 per digit, x-y coordinates panel, $36 each. **Radio Corp of America, 30 Rockefeller Plaza, New York 20.**

Circle 5, Reader Service Card

Frosted look for stainless steel . . .

is achieved by a type of semiblasting technique that forms tiny mounds on the surface. Process, which is applied very lightly and does not penetrate surface of metal, diffuses light rays. All kinds of patterns, lettering, bossed, deposed, flat or contoured surface can be provided by the new process. Also, finish is applied after forming. Finish is said to be applicable to any size, shape, type or gage of shiny stainless steel. Cost is comparable, in most cases, with painting. Process may be licensed. **Stamping Service Inc, 5500 Davison, Detroit.**

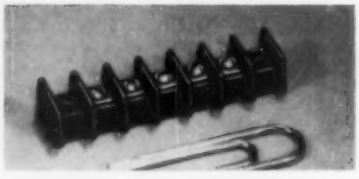
Circle 6, Reader Service Card

. . . CONTINUED ON PAGE 72

Ceramic for use to 5000 F . . .

is a reinforced material said to resist gas erosion at extreme temperatures and eliminate structural failure due to heat shock. Basically ceramic in nature, material is first of a family that uses different ingredients in fabrication. Normally brittle ceramic has been developed to be quasi-ductile. Excessive stresses cause material to deform rather than result in brittle, catastrophic fractures. Reports indicate that negligible changes in rocket-nozzle throats made of this ceramic have resulted at 5000 F for test durations of more than 60 sec with actual rocket motors. **Avco Research and Advanced Development Div, 201 Lowell St, Wilmington, Mass.**

Circle 7, Reader Service Card



Subminiature terminals . . .

are in various styles and lengths to fit a wide range of electrical and electronic usages, eliminate splicing, increase insulation, stop electrical leakage and shorts, and are said to simplify wiring work in tight spots. Molded of high-tensile-strength bakelite for commercial uses; available in other materials made in compliance with electrical specs or MIL-M-14. Blocks are made with 1 to 21 terminals, depending on size. **Kulka Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.**

Circle 8, Reader Service Card

Short-oil, nondrying alkyd . . .

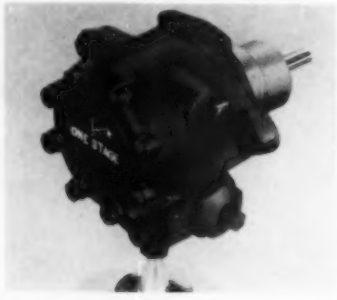
resin is said to be so resistant to weathering that enamels and lacquers based on it have max weather durability, color and gloss retention, high hardness and good flexibility. Enamels formulated with this resin have excellent hot hardness, toughness and resistance to marring and scratching. Also improves the weather durability of nitrocellulose lacquer finishes. With melamine and urea resins, rated very good; with vinyl resins, fair to good. Has good compatibility with zinc oxide and shows infinite tolerance for aromatic solvents, while mineral spirits can be used on a 1:1 basis. **Archer-Daniels-Midland Co, 700 Investors Bldg, Minneapolis 2.**

Circle 9, Reader Service Card

Unsupported Teflon tape . . .

in four grades is offered in widths from ¼ to 12 in. in ⅛-in. increments. Tapes, made by skiving Teflon billets, are offered in thicknesses of 0.002 to 0.060, 0.089 and 0.1 in. Characteristics of Teflon are generally retained. Grade ST-X offers the best electrical and physical properties; ST-C is similar, with slightly reduced properties and is available in nine colors; ST-1 is the standard grade from which cementable Teflon is made and meets most applications that do not require exceptionally high electrical or physical properties. Where virgin material is not specified, ST-2 offers lower cost. Supplied on rolls. **Continental-Diamond Fibre Corp, Newark, Del.**

Circle 10, Reader Service Card



Gear-type pumps . . .

for lubricating or hydraulic oils at pressures from 20 to 300 psi and speeds of 1200 to 1800 rpm max are offered in four pump capacities for left- or right-hand shaft rotation. Capacity of pumps ranges from 38 to 41 gph at 1200 rpm and from 57 to 62 gph at 1800 rpm. Roller design permits inner roller, keyed to shaft, to drive outer member at speeds 25% below motor speed. Pumps are supplied with piston-type relief valve in pressure ranges of 20 to 40, 40 to 80, 80 to 150 and 150 to 300 psi. Piston is hydraulically equalized to prevent cocking or sticking and desired pressure setting require only screwdriver adjustment. **Sundstrand Hydraulic Div, Sundstrand Machine Tool Co, 2210 Harrison Ave, Rockford, Ill.**

Circle 11, Reader Service Card

Hydraulic power unit . . .

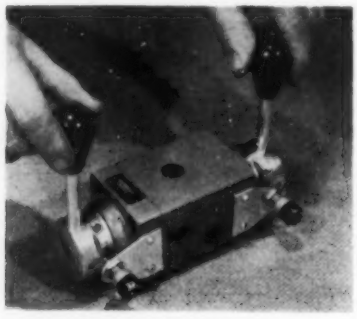
is offered with rotary gearpump capacities of ½ to 4 gpm at 1800 rpm; increased delivery at 3600 rpm. For pressures up to 2000 psi. 4¾ in. dia reservoir in lengths of 6, 9, and 12 in. is for 1½, 2½ or 3-qt capacities or 6⅝ in. dia for 2 gal or more. Ball-bearing motors are for continuous or intermittent duty. Standard ac motor is rated ½ through 2 hp; dc motor is for 6, 12 or 24 v. Built-in control variations include check and relief valve; manual or solenoid-operated lowering valves; unloading valves. **John S Barnes Corp, Constant-Flo Div, 301 S Water St, Rockford, Ill.**

Circle 12, Reader Service Card

Fast-drying metal finish . . .

is based on Parlon chlorinated rubber and a short-oil alkyd that permits tack-free drying times of 30 min. Finish is also said to exhibit increased hardness and mar-resistance, greater resistance to humidity and alkalies and acids, increased abrasion resistance and easier cleaning. Short-oil alkyd is available as a solution in xylene at 60% nonvolatile and weighing 8.3 lb per gal. Metal-finishing enamel is slightly lower in cost than a chlorinated rubber-medium oil formulation. **Hercules Powder Co, Wilmington 99, Del.**

Circle 13, Reader Service Card



Double hydraulic valve . . .

in 3- and 4-way combinations is offered in sizes from 2 to 40 gpm with detented or spring-return handles. Seals mating with optically flat rotor surfaces assure positive sealing at 2500-psi oil and 2000-psi water pressure. Valve incorporates roller thrust bearing. Motor starting switches can be added for ac or dc operation. Pump then runs only when handle is turned. Suitable for use in fork lifts, loaders, road machinery and machine tool applications. **Clark Engineering & Mfg Co Inc, 1820 Layard Ave, Racine, Wis.**

Circle 14, Reader Service Card

Tandem-ganged switch . . .

with three cups is rated at 100 milliamp per cup. Made to angular accuracy of 2° and with torque of less than 0.5 in.-oz. Unit is servo-mounted and uses precision ballbearings. Except for shaft end, unit is sealed from moisture and foreign materials. Available in standard and special mounting arrangements. Life is estimated at 2 million revolutions min. **Maurey Instrument Corp, 7924 S Exchange Ave, Chicago 17.**

Circle 15, Reader Service Card

Differential pressure unit . . .

transmits variations in pressure to an electrically operated receiving instrument, which may be an indicator or controller.

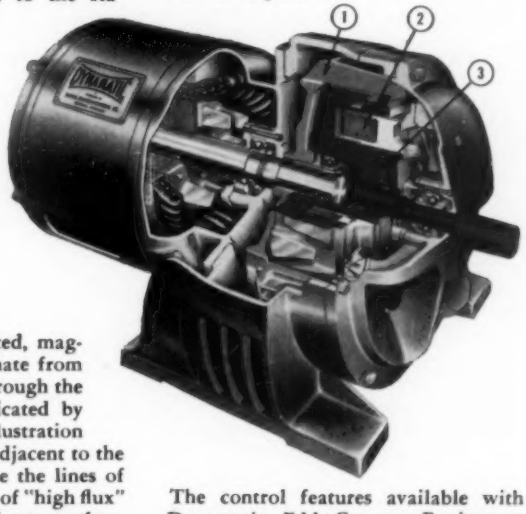
. . . CONTINUED ON PAGE 74

HOW DYNAMATIC® Drives Provide Infinitely Adjustable Speed with AC Power

Dynamatic Ajusto-Spede® and Dynaspede® Drives operate from an alternating current power source and are infinitely adjustable from zero RPM to full output speed. Accurate control of output speed is obtained by varying the current in a single field coil.

Each Dynamatic Drive consists of a constant speed AC motor and an eddy-current coupling. Torque developed in the motor is transmitted through the coupling by electromagnetic attraction between its driving and driven members.

The driving member, or drum (1), is mounted on the end of the motor shaft and surrounds the rotor, or driven member (3). The drum is free to rotate independently of the rotor until current is applied to the stationary field coil (2).



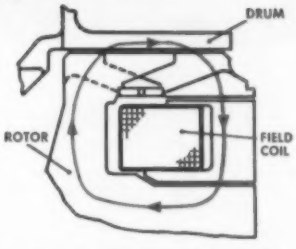
1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

As the field coil is excited, magnetic lines of force emanate from the field coil and flow through the rotor and drum as indicated by arrows in cross-section illustration (A). Poles on the rotor adjacent to the smooth drum concentrate the lines of force into localized areas of "high flux" density in the drum's inner surface, shown in illustration (B). As the drum rotates about the rotor, these high flux areas sweep the inner surface of the drum, causing a variation of flux density that generates an eddy-current field in the drum's inner surface. Magnetic attraction between this eddy-current field and the rotor poles causes the rotor to rotate with the drum.

The torque transmitted from the drum to the rotor varies with the current applied to the field coil and with the "slip", or difference in speeds between the drum and rotor. Speed control with eddy-current equipment is obtained with a control system that adjusts field coil current to deliver the required torque at the desired slip.

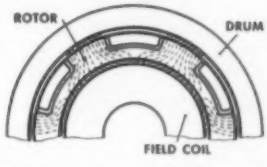
The control systems used with Dynamatic Eddy-Current Equipment operate on alternating current and require no special power source. Because of the low power required for field coil excitation, rectifying of field coil current is easily accomplished electronically. Expensive motor-generator sets are not required.

The control features available with Dynamatic Eddy-Current Equipment include constant speed regulation, acceleration control, torque regulation, cascading of multiple units, inching and threading, and numerous others as required by individual applications. Dynamatic Eddy-Current Equipment is ideally suited to automatic control.



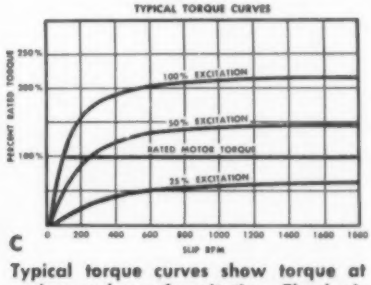
A

Flow of magnetic lines of force through rotor, drum, and stationary field.



B

Concentration of magnetic lines of force by the rotor poles.



C

Typical torque curves show torque at various values of excitation. The horizontal line is rated motor torque.

D

The electronic control systems used with Dynamatic Eddy-Current Equipment do not require a special power source or motor-generator sets.

Send for your copy of Bulletin D-582 which gives detailed information on Dynamatic Eddy-Current Equipment.

EATON®

EATON — DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

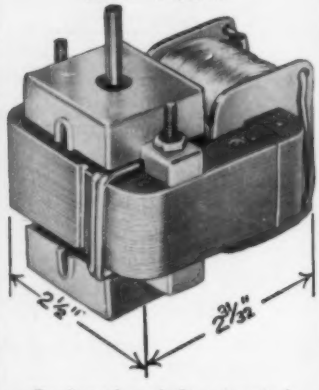
GENERAL INDUSTRIES

Smooth Power

AC MOTORS

1/1550 H.P. to 1/33 H. P

2-POLE
SHADED-POLE MOTOR
1/550 HP to 1/50 HP



Designed and Constructed with Features That Insure
EXTRA YEARS OF SERVICE

When exceptionally long service is a must, you can rely on GI's new Model H, 2-pole, shaded-pole motor. The Model H is constructed with many outstanding features that assure thousands of EXTRA HOURS of service under the most adverse operating conditions. Available in nine models that cover a wide range of applications.

OIL CAPACITY MANY TIMES GREATER THAN CONVENTIONAL MOTORS Oversized oil bearing reservoirs hold considerably more oil and wicking assuring more efficient lubrication over a longer period of time.

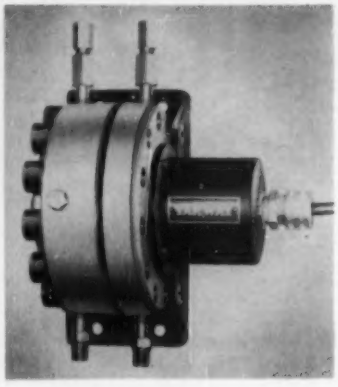
REVOLUTIONARY METHOD OF PACKING THE OIL WICKING A unique new method of packing the oil wicking assures equal oil distribution at all times resulting in quieter operation and longer, trouble free life.

DIE-CAST BEARING BRACKET This new "H" Motor design includes a rugged die-cast bearing bracket that insures permanent precision alignment and adds to the over-all durability.

Write today for catalog sheet and quantity-price quotations.

THE GENERAL INDUSTRIES CO.

DEPARTMENT GK • ELYRIA, OHIO



Transmitter is connected to liquid vessel, fluid line or container by two tubes that lead to opposite sides of a diaphragm mechanism, which is located in a pressure housing with pressure connections at bottom and sensing coil that operates remote receiver. Variation in differential pressure on diaphragm causes change in output of sensing coil. **Yarnall-Waring Co, Philadelphia 18.**

Circle 16, Reader Service Card

Miniature vibration pickup . . .

is eddy-current-damped unit with flat response curve over full operating range of 40 to 2000 cps, ±5%; 30 to 2000 cps, ±10%. Dimensions of 1.42 in. sq x 1 in. high are said to retain desirable characteristics of regular line of velocity pickups, including self-generation with no cathode follower or other impedance matching amplifier required, good temperature stability with high electrical output. Pickup weighs 2.75 oz. Tests indicate that acceleration to 50 g for continuous duty and to 100 g intermittently do not damage unit. Operates in temperatures of −85 to 500 F. Available from stock. **MB Mfg Co, PO Box 1825, New Haven 8, Conn.**

Circle 17, Reader Service Card

Cobalt tool steel . . .

is now stocked in square bars of ¼ to 6 in., as well as in rounds to 10 in. and flats to 4 x 10 in. Non-deforming, air-hardening high-carbon, high-chromium tool steel is said to have high strength, outstanding wear resistance and heat resistance to 1000 F. Conforms to AISI or SAE grade D5. Available in sand castings, forgings and hot-rolled annealed bars. **Darwin & Milner Inc, 2345 St Clair Ave, Cleveland 14.**

Circle 18, Reader Service Card

Flexible epoxy resin . . .

is stable in applications where continual changes of temperature or heavy impact loads break down more rigid epoxies. Ma-

(Continued on page 77)

TUBULAR
RIVET
COST-SAVINGS
MULTIPLY
WITH MILFORD'S
ASSEMBLY
ANALYSIS

1.
WE STUDY
THE
FUNCTION

2.
WE DESIGN
THE RIGHT
PART

3.
WE
RECOMMEND
THE BEST
ASSEMBLY
TECHNIQUE

Smart designers are getting an assist from Milford—not only with basic design tips—but with a complete Assembly Analysis from drawing board to finished product.

For the answers to assembly problems . . .
. . . get in touch with Milford first!

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

You're in for a Hot Time

but Fenwal's New Miniature

Hermetically Sealed THERMOSWITCH® Unit will control it—precisely!

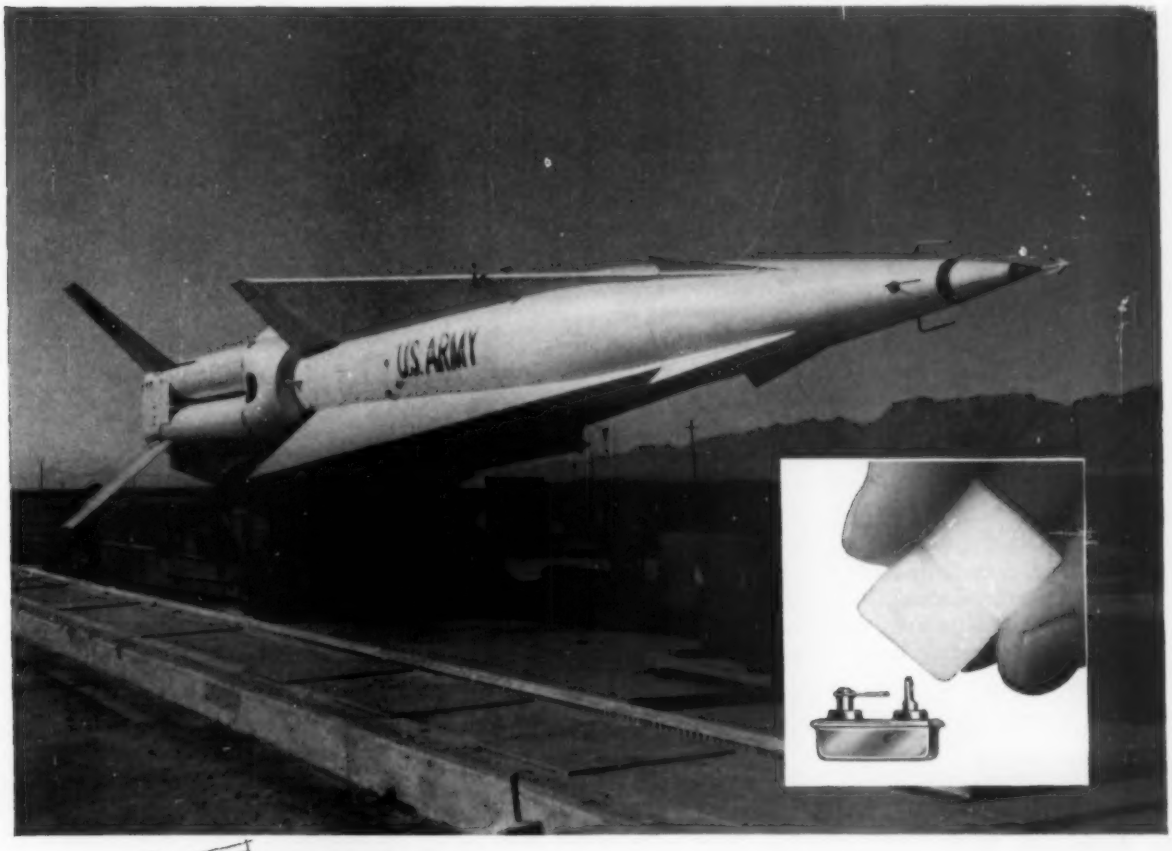
There'll be a hot time in the old ionosphere tonight. But with Fenwal's new Miniature Hermetically Sealed THERMOSWITCH Unit aboard everything will be under control. This tiny Fenwal unit responds quickly and accurately to temperature changes — *it's reliable!*

It's hermetically sealed, yet field adjustable. Even extreme vibration and shock won't upset its control characteristics — *it's built to take it!*

But most of all, this corrosion-resistant Fenwal unit does it all with exacting control of within 1° — in temperatures of −20°F to +200°F (−65°F to +220°F exposure limits). And it's the only unit that has all three features — *small size, ruggedness and precision control!*

If missiles are your business you'll want all the information on this tiny, tough, sensitive and reliable control. For more information on this unit or complete Fenwal temperature control systems, write for our catalog. If you want, we'll send our sales engineer, too. Fenwal Incorporated, 22 Pleasant Street, Ashland, Massachusetts.

The new Fenwal Miniature THERMOSWITCH Unit (compared here with a lump of sugar) weighs less than ¼ oz. Its current capacity is 2.5 amps, 115 VAC, 2.0 amps, 28 VDC. Widely used for crystal ovens, tuning forks, gyro assemblies, missile blankets and missile batteries.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Steam Requirements SLASHED 90% with Cold Bonderite System

50,000 lbs. of steam per hour *before*, 5,000 lbs. per hour *after* installation of Cold Bonderite System!

That's one of many amazing records being made in plants all over the country by this new Parker Rust Proof system.

The switch to Cold Bonderite requires no new equipment, no changes in layout, no new techniques to teach your crew. The specially formulated cleaner and Bonderite simply operate at greatly reduced temperatures, cutting heat requirements by 50 to 90%.

Results? Coatings of traditional Bonderite quality and uniformity with big heat and operating savings.

Nearly a hundred plants, in many industries, are cashing in on Cold Bonderite right now. Get this competitive advantage for *your* plant, too. Call in the Parker man in your territory and begin saving money now!

Temperature gauges tell the story. Special Parco Cleaners and Bonderites in Cold Bonderite System operate 40° to 75° cooler!

Since 1914 — leader in the field

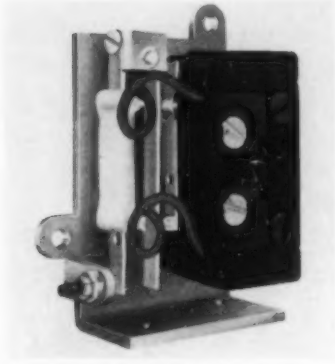
PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

jor application anticipated is as an adhesive, where changes in temperature tend to weaken bonds. Also suitable for tooling dies and fixtures, and encapsulation of electrical components. In liquid state, resin has low viscosity. In elongation tests at room temperature, casting stretched 100% before breaking, while rigid epoxies snapped when they had been stretched 7%. Commercially available at 95¢ per lb. **Shell Chemical Corp, 50 W 50th St, New York 20.**

Circle 19, Reader Service Card



Miniature time delay . . .
switches up to 20 amp. Snap-action load contacts are offered in many arrangements. Thermal device has automatic ambient temperature compensation, is self-recycling and adjustable. Available in explosionproof or hermetically sealed housing. Magnetic blowout dc or double-break load contacts may be specified. Possible applications are in air conditioning, refrigeration, heater controls, computers and simple recycling applications. **Industrial Timer Corp, 1407 McCarter Highway, Newark 4, NJ.**

Circle 20, Reader Service Card

Miniature potentiometer . . .
has variable-micrometer-type adjustment for selecting resistances from 10 to 150,000 ohm. Once set, remains at ohm setting under wide range of environmental conditions. High-temperature housing withstands 500 F. Trimmer potentiometer operates in temperatures of —67 to 392 F; withstands vibration of 20 g at 257 F and 100 g shock at 10 ms. Conforms to applicable military specifications for altitude, humidity and salt spray. Case is 1.140 x 0.312 x 0.210 in. and weighs about 2 gm. **Atohm Electronics, 7648 San Fernando Rd, Sun Valley, Calif.**

Circle 21, Reader Service Card

Reusable heater . . .
to stabilize temperatures of components or assemblies is molded to conform closely to external shape of specified unit. Pockets

(Continued on page 78)

Savings

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility

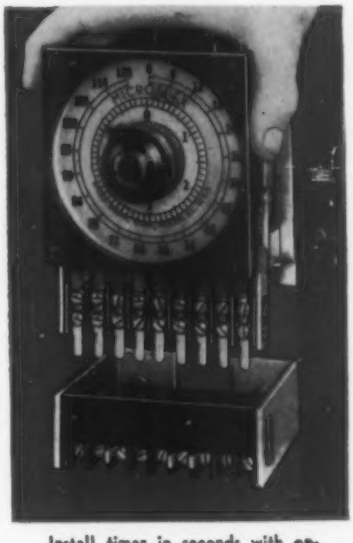
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

Reliability

- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. PE-359
MOLINE, ILLINOIS

Please send FREE Bulletin 110 containing complete data on Microflex Reset Timers.

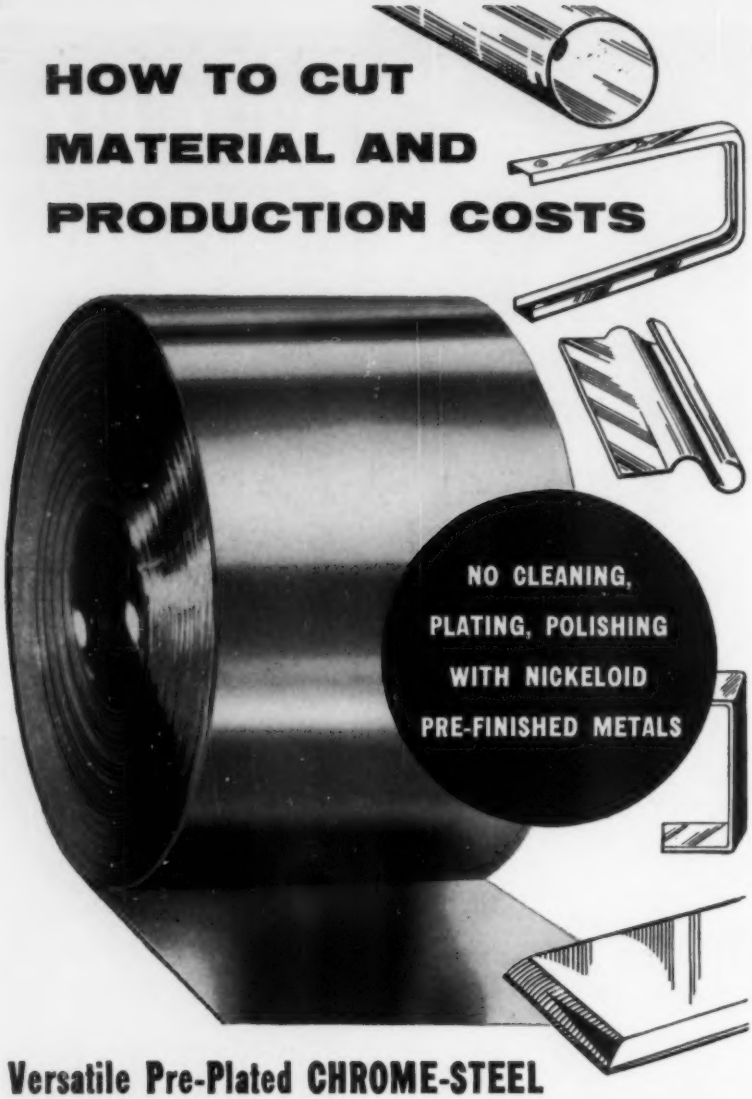
NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1898

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 4, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania

Sales Offices Throughout the U.S.A.

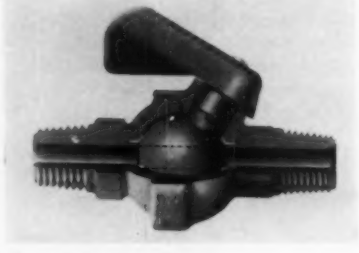
can be incorporated for button-type miniature thermostats. System, except for leads and thermostat, is nonmetallic and can dissipate up to 15 w per sq in. at temperatures to 302 F. Typical warmup time for an 8-oz assembly from —67 to 158 F operating temperature is 18 to 20 min. Clamping flanges for wrap-around package are molded-in and only mounting hardware is loose. Blanket weighs about 8 oz per sq ft. **Applied Technology Corp, 475 Fifth Ave, New York 17.**

Circle 22, Reader Service Card

160,000-psi locknut . . .

is said to offer a 20 to 42% weight reduction over comparable original hex nut series. Wrenches for this fastener are two sizes smaller than for standard AN and NAS nuts, permitting use of narrower flanges and allowing bolt to be placed closer to load centerline. Low-height, self-locking nut was especially designed for 160,000-psi short-thread screws and bolts. Also available in corrosion-resistant steel for 900 F. **Kaynar Mfg Co Inc, Box 2001, Terminal Annex, Los Angeles 54.**

Circle 23, Reader Service Card



Plastic ball valve . . .

provides a straight-flow nonturbulent pattern. Teflon seals and chemically resistant seals permit satisfactory performance under extreme exposure. Supplied in PVC types I and II and Penton ⅛ and ¼ in. IPS sizes and ¼-in. hose sizes. **Chemtrol, 10872 Stanford, Lynwood, Calif.**

Circle 24, Reader Service Card

Standard 1600-F bolts . . .

offered in airframe and engine configurations are fabricated from one of four metal alloys. Rated at a min tensile strength of 155,000 psi at room temperature, 135,000 psi at 1200 F and 85,000 psi at 1600 F. Rated min stress rupture life is 100 hr at 1500 F and 10 hr at 1600 F, in both cases

(Continued on page 81)

1649 TIMERS

that **SOLVED** special control problems.

• How this engineering experience can help you.

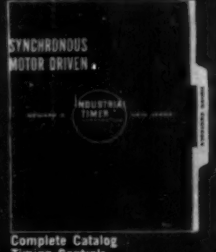
The small Time Delay Timer represents one of the simplest motor driven timers we manufacture. It is a reliable standard fixed time delay type.

Industrial Timer also manufactures this Punched Tape Programmer which controls 85 individual load circuits through an unlimited number of steps. No coding or elaborate memory systems are required, making possible direct control from Programmer to process.

Between these two extremes we list 1688 different timers, of which 39 are standard types and 1649 are "specials" developed to solve difficult control problems.

Most timing problems have their own unique characteristics. However, it very often happens that a control problem is quickly solved by one of these 1649 already developed special timers. If not, we have the staff, the experience (20 years) and what's more important, the desire to design and deliver the timer that fills your needs 100%. Send us your specifications.

COMPLETE NEW TECHNICAL BULLETINS NOW READY
Ask for complete catalog or individual bulletins by number



Complete Catalog Timing Controls

No. 100 Card & Tape Programmers

No. 200 Motor Driven Cam Timers

No. 201 Multi-Cam Timer Kit

No. 300 Motor Driven Time Delay Timers

No. 400 Motor Driven Interval Timers

No. 500 Motor Driven Recycling Timers

No. 700 Time Meters & Time Totalizers

No. 800 Explosion Proof Timing Controls

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1415 McCARTER HIGHWAY, NEWARK 4, N. J.

AFFILIATE—LINE ELECTRIC COMPANY

CONTOUR

Milsco
MILWAUKEE

SEATING

1st in Economical Quality Seating

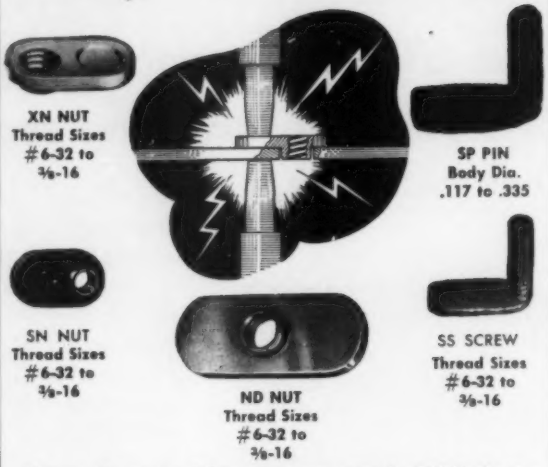
Add even more styling, comfort, and sales appeal to your mobile equipment with Milsco Contour Seating . . . first in features, first in value, first in economical quality!

Whatever your needs, whether immediate or for future reference, investigate the advantages of incorporating a Milsco Seat in your fine products. Detailed specifications are invited. If preferred, a representative will call.

DISTRIBUTOR TERRITORIES AVAILABLE

MILSCO MANUFACTURING COMPANY
2738 North 33rd Street, Milwaukee, Wis.
Telephone Hilltop 4-6030

OHIO SPOT WELDING FASTENERS



If you do spotwelding you can attach OHIO Spotweld Fasteners at the same time for faster, trouble-free assembly.

Samples and information available upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
41 FIRST STREET BEREA, OHIO

CIRCLE 136 READER SERVICE CARD

IMPROVED
HYDRONIC
REMOTE CONTROL
SYSTEM

- Completely Hydraulic
- Positive, Accurate
- 100% Responsive

FOR CONTROL OF ANY MECHANISM UP TO 100 FEET AWAY

The HYDRONIC System is a distinct advance in the remote control field. It offers all the advantages and simplicity of a self-contained hydraulic system. Backlash, motion inaccuracies and installation difficulties inherent in mechanical linkages or push-pulls are eliminated. The HYDRONIC System is unaffected by wear and vibration.

Master and slave levers maintain perfect synchronization even under wide temperature changes through 114° arc with 500 in. lbs. output in either direction. A simple adjustment permits instant relative positioning of levers.

Write for complete information today.

THE HYDRONIC COMPANY
12685 Arnold-Detroit 39, Mich.

CIRCLE 135 READER SERVICE CARD

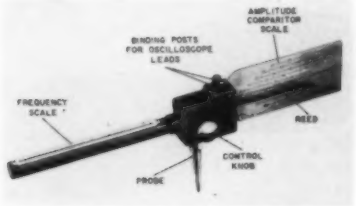
CIRCLE 137 READER SERVICE CARD

with sustained load of 30,000 psi. Bolts are external wrenching type with 12-point configuration. Initially, bolts will be produced in diameter sizes No 6 through 1¼ in. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 25, Reader Service Card

Microfilm viewer . . .
utilizes a 65mm f/4 lens. Covers full area of Military D aperture and projects complete drawing on an 18 x 24 in. screen. With nominal magnification of 15 times, unit enlarges A, B and C drawing sizes filmed at 16X reductions to almost full size. Larger drawings filmed at 30X reduction come back to half-size detail. Viewer screen remains dark until aperture card is inserted. Exhaust blower maintains temperature of less than 110 F when ambient temperature is 70 F. Unit is 26 x 27 x 31½ in. high. **Filmsort Co, Pearl River, NY.**

Circle 26, Reader Service Card



Hand-held vibration meter . . .
measures vibration frequency and amplitude, determines direction of max transmitted disturbances, locates cause of unwanted noise due to resonant vibration and measures speeds of rotation.

Steel strip, whose length can be varied by knob on side of the meter, acts as a reed. When natural reed frequency coincides with that of disturbance being tested, reed vibrates strongly in resonance. Scale marker on handle directly indicates frequency. Frequency range is 120 to 15,000 cpm.

Accuracy is within 10 or 3%, depending on frequency. Instrument weighs 1 lb.; measures 9¼ x 1⅜ x 1 in. With case, price is $55. **Korfund Co Inc, 48-19C 32nd Pl, Long Island City 1, NY.**

Circle 27, Reader Service Card

—check with

FAIRFIELD!

GEAR PERFORMANCE to match the ever-increasing power and speed of modern machines is a Fairfield specialty. This is possible because Fairfield has long held a position of leadership in utilizing the most advanced methods, equipment, and techniques for producing better gears. By keeping apace with modern engineering trends, Fairfield renders an invaluable service to many of the nation's leading machinery builders.

If you have a gear problem, check with Fairfield. Our engineers are well-qualified to give you expert recommendations. CALL OR WRITE.

SPUR GEARS—Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

HERRINGBONE—(Fellows Type). Sizes from 1½" to 15"

SPIRAL BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

STRAIGHT BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

HYPOID—Sizes from 1½" to 28" dia.

ZEROL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 21" dia.

WORMS AND WORM GEARS—Worms to 7" dia. Worm gears to 36" dia.

SPLINED SHAFTS—Lengths to 72".

DIFFERENTIALS—3,000 to 500,000 inch pounds capacity.

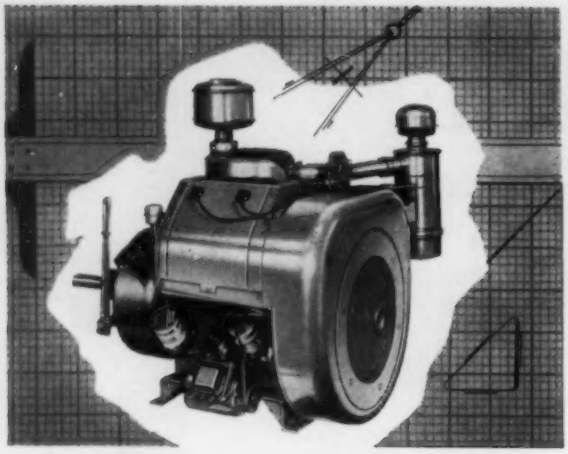
Note: All of the sizes above are approximate.

FAIRFIELD MANUFACTURING CO.
2305 South Concord Road • Lafayette, Indiana
TELEPHONE: 2-7353

Ask for interesting, illustrated bulletin.

Gears and Differentials Made to Order for:

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS



Let ***"Wisconsin"*** *Engineers help you develop a* complete power package for your equipment

You start with a rugged, heavy-duty WISCONSIN AIR-COOLED engine. Compact and light weight to reduce bulk and fit your equipment. High torque for load-lugging power. Air-cooling for all-weather serviceability in any climate, any weather, anywhere. Here are the "extras" available from Wisconsin to complete the "power package" to most ideally suit your requirements:

DRIVE: Centrifugal clutches; over-center clutch; clutch reduction with various ratios; reduction assemblies; adapters to take a spring-loaded clutch and transmission or torque converters.

SPEED REGULATION: Your choice of many types of governor controls . . . hand operated remote wire and lever controls; 2-speed agricultural controls (idle and load speed); provisions to mount controls of your own design.

FUEL SYSTEM: Gasoline and LPG for domestic applications; alcohol, kerosene, No. 1 fuel oil or kerosene for export (or as specified).

HYDRAULIC POWER: All Wisconsin 4-cylinder models can be equipped with integrally mounted hydraulic pump.

ELECTRICAL EQUIPMENT: 6- and 12-volt electric starters and generators for all models, 3 to 56 hp. Solenoid switches and automatic choke for remote or automatic starting.

Let us help you build the right Wisconsin Engine into your equipment . . . *power to fit the machine and the job.* Tell us about your problem. We'd like to co-operate. For a briefing on the Wisconsin engine line, write for Bulletin S-237.

WISCONSIN MOTOR CORPORATION Milwaukee 46, Wisconsin

82 CIRCLE 139 READER SERVICE CARD

When it's a Question of

"O" RINGS in any material or special compound for every service condition required.

PACKINGS to your specifications in leather, synthetics, asbestos, teflon, etc.

Also gaskets and washers in over 200 materials . . .

Look for the Answer at Auburn . . .

Send us your specifications or blueprints. You'll receive prompt quotations and recommendations without obligation

THE AUBURN MANUFACTURING CO.
306 Stack St., Middletown, Conn.

New York, N. Y.; Rochester, N. Y.; Detroit, Mich.; Chicago, Ill.; Minneapolis, Minn.; Pittsburgh, Pa.; Cincinnati, Ohio; Ridgewood, N. J.; Atlanta, Ga.; Memphis, Tenn.; St. Louis, Mo.; Washington, D. C.

CIRCLE 140 READER SERVICE CARD

Ultra High Precision Fine Pitch

MASTER SPUR GEARS

immediate delivery from stock

.0002 Maximum Composite Error
20 Pitch and Finer
14-1/2° and 20° Pressure Angles
Hardened and Ground Tool Steel
Quick Delivery on Non-stock Items

INVO SPLINE, INC.

2363 E. NINE MILE ROAD • HAZEL PARK, MICHIGAN
PHONE: SLOCUM 7-8840

CIRCLE 141 READER SERVICE CARD

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

QUICK-SEAL COUPLINGS – Bulletin QSR 58, 20 pp. Discusses straight-through, single check-valve and double check-valve couplings for hydraulic and pneumatic applications. Cross-section drawings are given for each basic type of coupling. Chart with information for selection of seals for couplings in various temperature ranges is provided, along with flow data, pressure data and information on caps and plugs. Titeflex Inc, Hendee St, Springfield 4, Mass.

Circle 28, Reader Service Card

ALUMINUM MILL PRODUCTS–Booklet, 24 pp. Lists and describes mill products, including characteristics and typical properties. Material is listed in tabular form wherever possible. Tables compare non-heat-treatable and heat-treatable wrought alloys. Kaiser Aluminum & Chemical Sales Inc, Dept NR-19, 919 N Michigan Ave, Chicago 11.

Circle 29, Reader Service Card

OIL, WATER AND AIR VALVES–Catalog 59-60, 20 pp. Covers manual, foot-operated and solenoid valves for pressures from vacuum to 10,000 psi. Typical flow patterns, illustrations, port sizes, ordering data and valve numbers are shown. Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.

Circle 30, Reader Service Card

VARIABLE-SPEED PULLEYS–Catalog 70, 24 pp. Describes line of variable-speed and combination pulleys. Explains pulley controls. Charts describe sizes, ratings and how to select proper drive. Lewellen Mfg Co, Columbus, Ind.

Circle 31, Reader Service Card

PILOT-OPERATED SOLENOID CONTROL VALVES–Bulletin 582-A, 4 pp. Covers sizes, dimensions, construction and design features, model numbers and ratings of single and double-solenoid control valves. Hunt Valve Co, Salem, Ohio.

Circle 32, Reader Service Card

SINGLE-PHASE MOTORS – Bulletin 470-B, 4 pp. Describes line of integral horsepower, single-phase motors. Includes tabulated ratings, dimensions and weights. Robbins & Myers Inc, Springfield, Ohio.

Circle 33, Reader Service Card

PERFORATED REFRACTORY GAS-AIR BURNERS–Bulletin PR-1, 4 pp. Presents features, sizes and ratings of burners. Simplified chart shows range of capacities. Sizes, port area, weight and dimensions are listed. Selas Corp of America, Dresher, Penna.

Circle 34, Reader Service Card

ADJUSTABLE, FLARELESS UNION ASSEMBLY–Catalog sheet ER-0022, 2 pp. Information on service range and installation procedure, size and dimensions by part number of adjustable union. Weatherhead Co, 300 E 131st St, Cleveland.

Circle 35, Reader Service Card

BUTYL RUBBER COMPOUNDS–Bulletins 105-1 and 102-1, 12 and 8 pp, respectively. Reports on resistance of butyl rubber compounds to ozone and fire-resistant hydraulic fluids. Thiokol Chemical Corp, 780 N Clinton Ave, Trenton 7, NJ.

Circle 36, Reader Service Card

FHP MOTORS–Bulletin S-1, 12 pp. Lists and describes 300 standard reducer and nonreducer motors of various types and sizes. Includes ratings, specifications and dimensional drawings. Bodine Electric Co, 2500 W Bradley Pl, Chicago 18.

Circle 37, Reader Service Card

HOLLOW-SHAFT SPEED REDUCERS–Catalog HSDR-58, 12 pp. Contains parts indexes, unit dimensions, dimensions for high- and slow-speed shaft bores, plans and elevations of all shaft arrangements and tables of weights for torque arm and flange-mounted, double-reduction hollow-shaft, worm-gear speed reducers. Winsmith Inc, 23 Eaton St, Springville, Erie County, NY.

Circle 38, Reader Service Card

STRAIN GAGES, INSTRUMENTS AND ACCESSORIES–Specification and price list 4310, 24 pp. Lists over 250 types of bonded-filament resistance strain gages with electrical and physical specifications, prices and discount information. Baldwin-Lima-Hamilton Corp, Waltham, Mass.

Circle 39, Reader Service Card

REINFORCED MOLDING COMPOUND–Folder, 4 pp. Discusses design and molding advantages of glass-reinforced polyester molding compound, said to be 20% lower in cost than comparable molding compounds. Tables give physical, elec-

(Continued on page 85)

Features that set them apart from whatever is "second-best"!

SPHERCO®
SPHERICAL BEARINGS & ROD ENDS

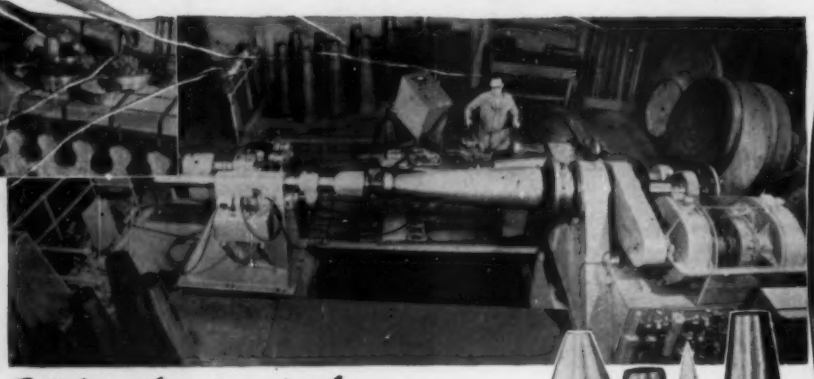
Quality SPHERCO Bearings and Rod Ends are precision built for superior performance. They are available in a wide range of sizes of varying design and materials to meet specific requirements. A SPHERCO engineer in your area will be happy to help you with your problems.

WRITE FOR CATALOG 257

SPHERCO
A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
9 RIDGEWAY AVE. • AURORA, ILL.

Announcing

COMPLETELY FLEXIBLE PHOENIX Powerspinning



Assembly produced by Spin-Fab method

We've bridged the gap

between primitive metal forming and amazing new techniques that meet the challenge of the space age.

First with the *world's largest horizontal spindle metal spinning lathe*, Phoenix is *first* again with *completely flexible POWERSPINNING* to form diameters, gauges and metals heretofore thought impossible to spin.

Components or assemblies of tough "exotic" metals or everyday type of work can be produced economically with Phoenix *automatic*, *mechanical* and *manual* spinning equipment in conjunction with complete *welding*, *polishing*, *deep drawing* and allied facilities.

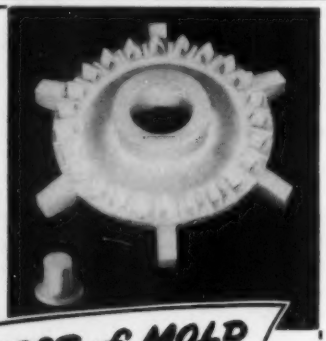
Immediate attention given to all inquiries. Visit our plant. See up-to-the minute equipment.

Write us for Product Engineering's Phoenix story and 32 page manual.

PHOENIX PRODUCTS CO.
4757 N. 27th St. • Milwaukee 9, Wis.

CIRCLE 143 READER SERVICE CARD

Savings on your first order for moldings will, in many instances, more than



COVER COST of MOLD

*New trademark for Du Pont nylon resin

And thereafter you may look for savings on raw materials, machining, and finishing that will cut the production costs of your parts to half . . . or even less.

That is why some of the country's leading manufacturers, like the Briggs and Stratton Corp., look to us for many of their precision-made parts. Pictured above is an oil slinger gear and stop switch button we molded for them of wear-resistant Zytel.* This superior plastic makes for quiet operation, and withstands extreme temperatures.

WE MOLD ALL THERMOPLASTICS—2 TO 175 OZ.

Sinko MANUFACTURING and TOOL CO.
7310 W. WILSON AVE. • CHICAGO 31, ILL.

Offices in Principal Cities Throughout the United States

PRECISION CAMS and CAMSHAFTS

All Types . . . Experimental and Production

Special Drum Type Cam

TWO AND THREE DIMENSIONAL CAMS
for Ballistic, Computer and Instrument Use—Milled or ground to ± .0001" tolerance

Face Type Cam

FACE AND CYLINDRICAL CAMS
milled or ground to ± .0002" tolerance

CAMSHAFTS
Aircraft, Automotive, Diesel Marine, Fuel Injection

Camshaft for Internal Combustion Engine

EONIC Inc. Engineers of Precision

Write for catalog and additional information

459 E. Hollywood • Detroit 3, Michigan

CIRCLE 144 READER SERVICE CARD

CIRCLE 145 READER SERVICE CARD

trical and chemical properties. Also includes recommended molding conditions, price schedules, delivery and shipping information. Atlas Powder Co, Wilmington, Del.

Circle 40, Reader Service Card

SLIM LINE VALVES—Bulletin 581, 4 pp. Ratings and dimensions of compact control valves, solenoid, lever or ball-actuated. Hunt Valve Co, Salem, Ohio.

Circle 41, Reader Service Card

SILICONE PRODUCTS—1959 Reference Guide, 16 pp. Describes silicone products ranging from adhesives to release agents, resins to rubbers, dielectrics to water repellents. Expanded indexing system facilitates use of the guide. Dow Corning Corp, Midland, Mich.

Circle 42, Reader Service Card

STAINLESS TUBULAR PRODUCTS—Data folder TDC-190, 8 pp. Contains data on analyses, corrosion and oxidation resistance, high- and low-temperature characteristics, physical and mechanical properties of 18-8 stainless steels. Babcock & Wilcox Co, Beaver Falls, Penna.

Circle 43, Reader Service Card

GLASS FIBER SLEEVING AND TUBING—Selection guide, 6 pp. Contains selection factor chart, charts of standard NEMA sizes and identifying grades and performance characteristics, government specifications, properties and applications of sleeving and tubing and NEMA definitions and classes. Owens-Corning Fiberglas Corp, Dept 860, 598 Madison Ave, New York 22.

Circle 44, Reader Service Card

SISAL-PHENOLIC MATERIAL—Data sheets, 4 pp. Two-step molding compounds, RX-825 and RX-831, are described. Compound and molded properties and recommended molding temperature and compression molding pressure are given. Rogers Corp, Rogers, Conn.

Circle 45, Reader Service Card

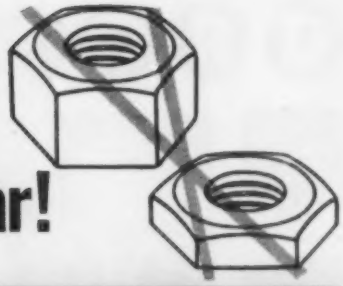
WELDED STEEL TUBING—Brochure, 4 pp. Sizes, weights, uses and checklist of ordering information are included. Covers hot- and cold-rolled mechanical tubing, predipped and hot-dipped galvanized. Wheatland Tube Co, 1300 Bankers Securities Bldg, Juniper and Walnut Sts, Philadelphia 7.

Circle 46, Reader Service Card

PUSHBUTTON ACTUATORS—Data sheet 155, 2 pp. Shows how six catalog listings in series allow use of a selection of basic switches. Charts give typical current and circuitry requirements and shows which basic switch may be used with the

(Continued on page 87)

Save 65¢ on each Fastener Dollar!



Replace expensive heavy nuts and jam nuts with low-cost, vibration-proof

PALNUT TYPE R LOCK NUTS

All PALNUT Lock Nuts provide attractive savings—but in sizes from ⅜" and up, the ratio of economy increases dramatically. On many applications, Type R PALNUT Lock Nuts can do the job better, at ⅓ the price! PALNUT spring-tempered steel lock nuts provide rugged assembly for loads in shear and moderate tensile loads, in sizes up to 2½" diameter. In addition, you get the following design and cost advantages:

- Vibration-proof assemblies without lockwashers.
- Save Space—need only 3 bolt threads, permit shorter bolts.
- Save Weight—PALNUTS weigh 65% less than plain nuts, 80% less than plain nut and lockwasher.
- Precision Made—always fit screw threads.
- Fast Assembly with hand or power tools.
- Sizes from #3-48 Machine Screw through 2½" American Standard Heavy.

Above: A ⅜"-18 PALNUT securely fastens inlet nipple in airplane brake assembly.

Right: A ¾"-20 PALNUT used on base assembly of food mixer.

Above: A 1"-14 PALNUT holds rear view mirror bracket to cowl of automobile.

Write for literature and free samples, stating type, size and application.

THE PALNUT COMPANY, 65 Glen Road, Mountainside, N. J.

In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

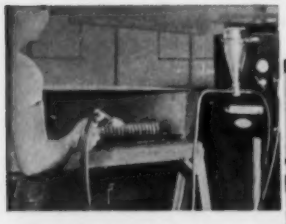
PALNUT® LOCK NUTS FASTENERS

PAL

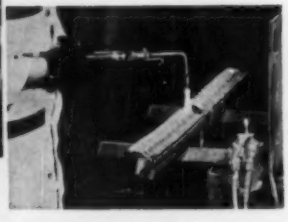
Quick, secure fastening at low cost

Colmonoy Spraywelding INCREASES Rocker Arm Life

Colmonoy No. 6 hard-facing alloy stopped the excessive metal-to-metal wear between the rocker arms shown and the cast iron cam shafts that operate them. Wear resistant Colmonoy No. 6 is sprayed on with the Colmonoy Spraywelder and fused in with an oxy-acetylene torch.



Rocker arms being sprayed with the Spraywelder.



● After spraying, the overlay is fused to the base metal.

Colmonoy Spraywelding makes hard-facing a real cost cutter. It allows the use of less costly base metals, speeds application time, and saves material and finishing time because overlays are smooth and within .010" of desired size.

Write for the Sprayweld Catalog. For a specific recommendation tell us about your part, and the wear encountered.

HARD-SURFACING AND BRAZING ALLOYS

WALL COLMONOY CORPORATION

19345 John R Street • Detroit 3, Michigan

BIRMINGHAM · BUFFALO · CHICAGO · HOUSTON · LOS ANGELES
MORRISVILLE, PA. · NEW YORK · PITTSBURGH · MONTREAL · GREAT BRITAIN

CIRCLE 147 READER SERVICE CARD

Shown 1½ Times Actual Size

DYNACO HOLLOW SHAFT DIFFERENTIAL

NOW

Stock Prices

Immediate Delivery

1/16" Face Width

MINIATURIZED GEARS

1/32", 1/16" & 3/32" Face Widths Available

PRECISION CLASS 1 & 2

72, 96 & 120 dia. Pitch with 20° Pressure Angle

Assembled gears available in aluminum or stainless steel...all have stainless steel hubs, pinning.

Bore Size
.0937 through .1875
Face Width
Pinions 3/32"
Overall
.218 and .250

FREE!

Send for Supplement "B" of E88 Dynaco Catalog

DYNAMIC GEAR CO. INC.
20 Merrick Road
Amityville, N.Y.
Phone AM 4-4788

CIRCLE 148 READER SERVICE CARD

Standard Plastic Knobs

Save the expense of making molds. Specify Standard Knobs and other Standard Plastic Parts, available from Waterbury's extensive selection of stock molds. Send for the following catalogs:

THERMOSETTING KNOBS
Phenolic or urea — will withstand heat.

THERMOPLASTIC KNOBS
Variety of colors at economical prices.

EYELETS, FERRULES, TERMINALS
In copper, brass, steel, and aluminum.

WATERBURY Companies, Inc.
ESTABLISHED 1812
PLASTIC MOLDING · METAL PARTS · METAL BUTTONS
651 RIVER STREET, WATERBURY 20, CONN.

CIRCLE 149 READER SERVICE CARD

actuators to meet each requirement. Dimensional drawings are included for two button sizes. Micro Switch, Freeport, Ill.

Circle 47, Reader Service Card

POLYESTER GLASS LAMINATES—Brochure, 4 pp. Describes grades and properties of polyester glass laminates, and suggests applications. Also describes custom moldings available. Presents physical, mechanical and electrical properties in tabular form. Continental-Diamond Fibre Corp, Newark, Del.

Circle 48, Reader Service Card

OVERHEAD-VALVE ENGINES—Bulletins E-301-A, E-303-A and E-305-A, 2 pp each. Describes, respectively, 4, 6 and 3-cyl models of interchangeable engines for use with gasoline, kerosene, LPG or natural gas. With photos of models, basic installation diagram, general data, power chart and specifications. Hercules Motors Corp, 101 11th St SE, Canton 2, Ohio.

Circle 49, Reader Service Card

BALL VALVES—Data sheet WF 1538, 2 pp. Characteristics, range and features of all-metal ball valves. Cutaway view illustrates operating principle. Waldorf Fluid Systems, Div F C Huyck & Sons, Wolf Hill Rd, Huntington Sta, LI, NY.

Circle 50, Reader Service Card

GAS SERVO SYSTEM—Booklet GEA-6846, 4 pp. Discusses design of system and applications. Describes high temperature capability and energy sources. General Electric Co, Schenectady 5.

Circle 51, Reader Service Card

PRESSURE TRANSDUCERS—Bulletins 58-131, 58-135, 58-140, 2 pp. each. Contains instrument descriptions, performance specifications, dimensions and application information. BJ Electronics, Borg-Warner Corp, 3300 Newport Blvd, Santa Ana, Calif.

Circle 52, Reader Service Card

MILL MOTOR COUPLINGS—Brochure, 4 pp. Covers design features and operation of all-steel self-aligning couplings for tapered shaft-ends in shaft sizes ¾ to 6¾ in. Table shows mill motor ratings and dimensions. Koppers Co Inc, 200 Scott St, Baltimore.

Circle 53, Reader Service Card

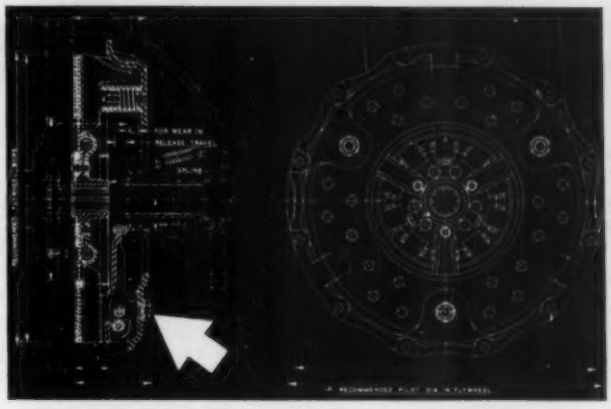
FLANGED SPHERICAL CORNERS—Catalog sheet 591, 2 pp. Gives dimensions and prices for prefabricated spherical corners with a tangent flange. Conner Steel Products, Dept PE, 24690 Telegraph Rd, Detroit 41.

Circle 54, Reader Service Card

OPTICS—Catalog 589, 96 pp. Lists more than 1000 optical items and instruments. Edmund Scientific Co, Barrington, NJ.

Circle 55, Reader Service Card

ROCKFORD



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

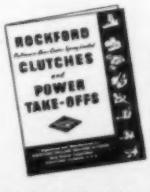
PATENTED

Patent No. 2818952

CLUTCH LEVERS

Reduce friction and wear • Improve clutch release action • and Prevent lever throw-out

Patented rolling fulcrum pin action, in the release lever, results in much less friction and wear, and smoother release operation in this clutch than in some other types of clutches. Pin automatically returns to original position. Carefully balanced levers avoid lever throw-out at high speeds.



SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

209 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

9 Reasons Why You Need

Rowbottom for Cams

1. Rowbottom offers the longest experience because this organization is the pioneer in cam development.

2. Rowbottom is a specialist, producing cams and cam-making machines **exclusively.**

3. Rowbottom produces every type cam in any size or quantity.

4. Rowbottom service is two-fold: producing cams exactly to your specifications acting as your "Cam department" or furnishing Cam Millers and Cam Grinders for production of your cams in your own shop.

5. Rowbottom service is **complete** . . . from assistance in design through the last detail in manufacture.

6. Rowbottom high quality service applies whether you need a single cam or thousands.

7. Rowbottom service also includes cams hardened and ground for specially tough service conditions; dimensional requirements are met to closest tolerances.

8. Rowbottom offers all these advantages backed by complete production and engineering facilities and through competent specialists in every phase of cam manufacture. This service includes also rotary profiling.

9. Rowbottom service is prompt as well as complete . . . and prices are **RIGHT.**

Hardened and Ground Index Cam

"Male" Barrel Cam

Diesel Engine Cam

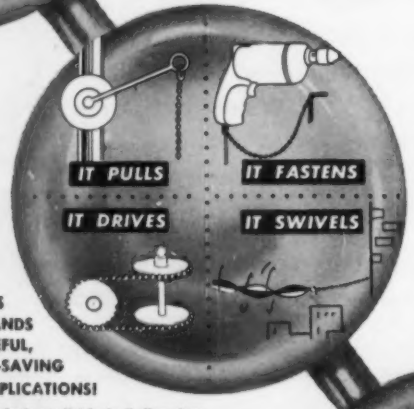
Ask for new brochure just off the press. Send us your specifications on the cams you need.

The ROWBOTTOM MACHINE CO.

30 SHEFFIELD ST. WATERBURY, CONN.

CIRCLE 151 READER SERVICE CARD

take advantage of *Versatile* **BEAD CHAIN**



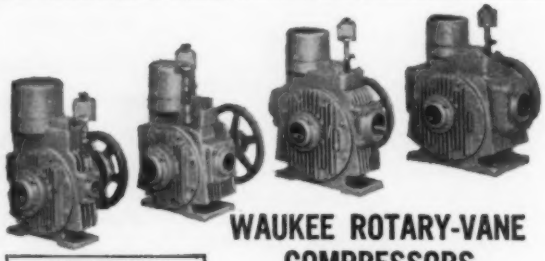
IT HAS THOUSANDS OF USEFUL, COST-SAVING APPLICATIONS!

Bead Chain is available in 5 diameters from 3/32" to ¾" with tensile strengths ranging from 18 to 200 lbs., in a variety of metals and finishes. No matter what the requirement, our engineers will be glad to assist you in solving your chain applications.

For complete information send for FREE HELPFUL CATALOG

THE BEAD CHAIN MANUFACTURING CO.

92 Mountain Grove St., Bridgeport, Conn.



WAUKEE ROTARY-VANE COMPRESSORS

with built-in pressure regulator 400 to 6000 CFH at 1 to 3 psi

CAPACITY TABLE			
Model	CFH	Approx. RPM	Motor Size
B	400	650	½
C	600	700	½
D	750	850	½
H	1000	750	½
J	1250	850	¾
E	1500	1050	1
K	2000	750	1
L	2500	900	1½
M	3000	1100	1½
P	4000	700	2
T	5000	850	2
V	6000	1000	3

Waukee Compressor: shows rotor and blades; automatic by-pass regulator piston and diaphragm assembly.

For complete specifications, write for Bulletin 430.

The Waukee Compressor supplies a steady flow of pulsation-free air or gas mixtures at pressures of 1, 2, or 3 psi. Featuring air cooling, rotary-vane construction, and a built-in automatic by-pass regulator, the Waukee Compressor is smooth, quiet and dependable. Also available for vacuum application.

Whether for OEM or replacement use, the Waukee Compressor provides a neat, sturdy, compact installation. Its rotary-vane design has few moving parts; no metal-to-metal contacts. Ball bearings are permanently lubricated with silicone grease. This simple construction means that any good mechanic can service a Waukee Compressor.

Waukee ENGINEERING CO.

5145 N. 35th St. • Milwaukee 9, Wis.

makers of Waukee gas Flo-Meters • Mixors • Washers

DESIGN ABSTRACTS

AIEE Winter General Meeting, Feb 1-6

For copies of papers: AIEE, 33 W 39th St, New York 18.

Speed Control of AC Motors

A drive using saturable reactors and wound-rotor motor to provide adjustable constant-speed control comparable to dc variable-voltage systems is described. Line contactor connects system to power line. All regulating components are static. Motor currents are controlled in all three phases for motor heating.

"Adjustable Speed Control of AC Motors," L R Foote, General Electric Co; AIEE paper CP 59-84.

Simplifying Boolean Functions

Two new methods of simplification and transformation of Boolean functions are presented, which are said to avoid some of the restrictions encountered in previous procedures. Rules for simplifying and transforming are given.

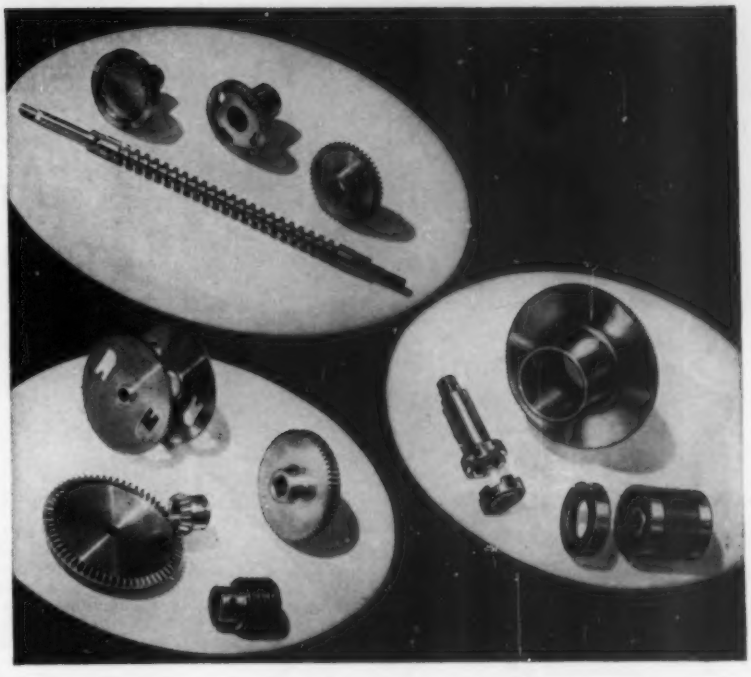
"New Methods of Simplifying Boolean Functions," R L Howard, Westinghouse Electric Corp; AIEE paper 59-91.

Three on Designing by Computer

"Optimum Machine Design by Digital Computer," by G L Godwin, Westinghouse Electric Corp (AIEE paper 59-57), states that errors in machine design calculations carried out by computer were just about nonexistent. Designing cost is about the same. Savings must come from better use of materials, greater sales, better product performance. Some predictions of probable future applications to design are made.

"Motor Speed-torque Curves by Digital Computer," by J M Shulman, Westinghouse Electric Corp (AIEE paper CP 59-133), points out the costliness of extensive speed-torque testing, then discusses limitations encountered when verification of design calculations is attempted on analog computers. Gives advantages, procedure for application of digital equipment.

"Synthesis of Induction Motor Designs on a Digital Computer," C G Veinott, Reliance Electric & Engineering Co (AIEE paper CP 59-131), describes process involved in engineering motors of this type; explains how computer can best be applied.



small and fine pitch gears for precision equipment

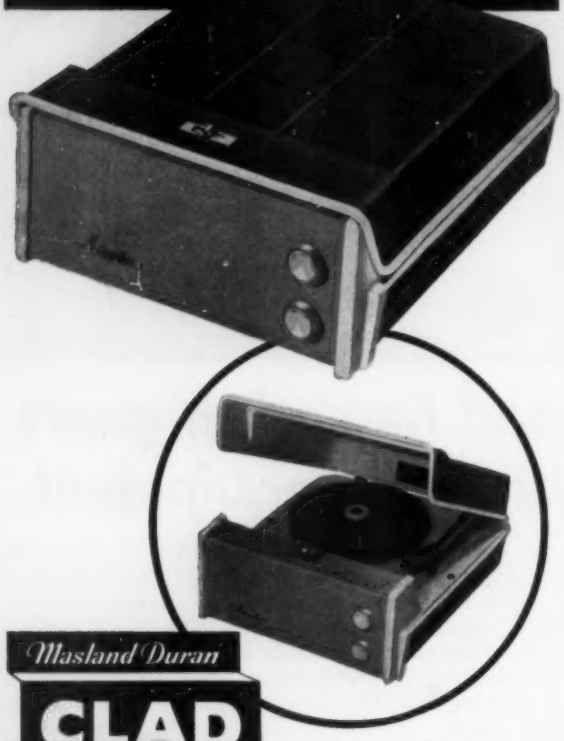
No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.

YOURS ON REQUEST Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 72 West Springfield, Mass.
Telephone: REpublic 7-4751

for *ANY* product it's more than just a *SURFACE* advantage



Masland Duran
CLAD
vinyl finish

Masland Duran CLAD used on Arvin phonograph

More than a finish! As an integral part of your product this versatile vinyl can provide a "built-in" sales advantage. It can be laminated permanently to metal. It can be formed, stamped, crimped, bent, shaped or drilled without impairing its textured look. No new equipment required. Durable and easy to keep clean. Mail coupon for samples.

Industrial Products Division
THE MASLAND DURALEATHER CO.
Dept. PE, Philadelphia 34, Pa.

THE MASLAND DURALEATHER CO., Dept. PE
Amber and Willard Sts., Philadelphia 34, Pa.
Please send folder and samples of Masland Duran Clad:
NAME_____ **TITLE**_____
COMPANY_____
STREET_____
CITY_____ **ZONE**____ **STATE**_____

CIRCLE 155 READER SERVICE CARD

electric clutch-brake for automatic positioning

electric motion control IDEAS

simplifies machine control

You may be able to eliminate index plates, high-pressure clamping, and other costly devices that normally go with automatic positioning. With an electric clutch-brake to control the drive, your machine can be positioned automatically using almost any mode of control from electric eyes to punched tape. Direct electrical operation simplifies design and reduces equipment costs. Lightning-fast engagement in any position when called for by the controller permits accuracy well within the range of most work. Write for Catalog No. 6292.

WARNER **Warner Electric Brake & Clutch Co.**
Beloit, Wisconsin

CIRCLE 156 READER SERVICE CARD

"How to write for

Product Engineering" . . .

. . . is a new 8-page pamphlet hot off the printing press.

It includes sections on:

"What Your Readers Want to Know"
"How to Select a Topic"
"What Makes a Good Article"
"What Not to Worry About"
"How You Can Ease Your Job"
"How We Pay Our Authors"

If you've ever thought about trying your hand at writing, drop us a note on your company letterhead. We'll send the booklet at no cost to you. If you have engineering friends who might also be interested, send us their names, titles and company addresses. We'll send a booklet to each.

Write: Att: Managing Editor

Product Engineering
330 W. 42nd St.
New York 36, N. Y.

NEW BOOKS

Engineering Drawing, 2nd Edition

FRANK ZOZZORA, *University of Delaware. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 8½ x 11, 440 pp. $6.50.*

Text is brief, concise and to the point. Superfluous material has been avoided, and specialized material appears only where needed to clarify or simplify certain aspects of the subject.

New chapters on "Structural Drawing," "Charts and Graphs," "Electrical Drafting," and "Descriptive Geometry" have been added to this edition. The chapter on freehand drafting has been expanded, and several new constructions are presented in the chapter on "Geometrical Construction." New features include tolerance dimensioning for surfaces. Geometrical form and position have been included in the "Dimensioning" chapter. Sections on jigs and fixtures have been added to the chapter on "Cams and Gears."

Structure of Steel

E GREGORY *and* E N SIMONS. *Published by Philosophical Library Inc, 15 E 40th St, New York 16. 5½ x 8½, 176 pp. $10.*

"A simple explanation for students, engineers and buyers." This description given on the dust cover of the book is well put but somehow one feels that for the high price one should get more than a simple explanation. It is a good primer if you have never taken a course in basic metallurgy, but if you have, pull out your old textbook and look it over again.

Effect of Metals on Lubricants

JOHN B CHRISTIAN. *PB131710, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 29 pp. $1.*

This report presents data which deals with the general effects which silicates and siloxanes have on various metals. It was found that aluminum retained its freshly polished finish, lost no weight, and showed no pitting or etching. It was unaffected by all of the fluids tested with it. It also had little or no effect on any of the fluids.

Brass was slightly etched and dis-

(Continued on page 93)

Simpler, More Compact Hook-Ups with
ANCHOR® SAE STRAIGHT THREAD "O" RING BOSS FITTINGS
PLUS
ANCHOR® BOSS TYPE HOSE ASSEMBLIES
(For High and Medium Pressures)
Neat, orderly, compact—ready for connection to any valve port conforming to SAE Straight Thread "O" Ring Boss specifications—you'll appreciate them most when making connections in closely confined areas.
The "O" Ring seal assures leak proof connections.
For complete details write for Anchor Catalogs, No. 101 and No. 204.
ANCHOR COUPLING CO. INC.
368 No. Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

CIRCLE 157 READER SERVICE CARD

PUMPS ON YOUR MIND?
VIKING POSITIVE DISPLACEMENT PRINCIPLE
VIKING MULTI-RING HEAVY DUTY PUMPS
VIKING LARGE GENERAL PURPOSE PUMPS
Send for this VIKING Pump Data
VIKING ENGINEERING DATA
A 36-page pump engineering manual is yours for the asking. It fully explains the 10 easy steps in selecting Viking rotary pumps. Ask for catalog KX.
VIKING HEAVY DUTY PUMPS
Available in 10 to 1050 G.P.M. sizes, these rugged Vikings are suitable for pressures up to 200 PSI. Complete with specifications, performance data, etc., they are illustrated in the 24-page catalog CX.
VIKING GENERAL PURPOSE PUMPS
These Viking Pumps — in 2/3 to 1050 G.P.M. sizes — are suitable for pressures up to 100 PSI. They are fully illustrated and have specifications, performance data, etc., in the 36-page catalog BX.
All Viking Pumps are positive displacement pumps and deliver either thin or thick liquids.
VIKING — the leader, not a follower, in Rotary Pumps
VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps
See Our Catalog in Sweets' Product Design File

CIRCLE 158 READER SERVICE CARD

Miniature headless slotted Set Screws

Moore will meet your requirements for quality, price, and delivery

Here are miniature set screws made to the accuracy and quality which have built Moore's reputation for dependability. Hardness, threads, and sizes are quality controlled to assure precision uniformity.

Use Moore Miniature Set Screws . . . a fast, dependable source for one or a million. Available in #0 (prices on application), #1, #2, #3, #4 sizes in a wide selection of materials, finishes, lengths and points.

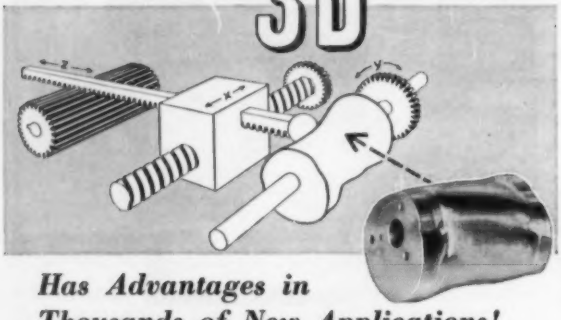
Moore prices are right . . . send for detailed price catalog

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
92 Beaver St., Waltham 54, Mass.

CIRCLE 159 READER SERVICE CARD

MECHANICAL 3D CONTROL



Has Advantages in Thousands of New Applications!

3 Dimensional Cams can be used in applications where "x" and "y" are input variables of • temperature • pressure • R.P.M. • liquid flow • speed • altitude • or any of thousands of other forces or motions.

The resultant "z" is the instantaneous function or readout of the two input variables. $z = f(x,y)$.

NEW

Some advantages • withstand severe environmental extremes • smaller control size • lighter control weight • dependability

NOW AVAILABLE . . . the latest and most complete brochure on 2 and 3 dimensional cam control. Fully illustrated and diagrammed design, development, application information. Send for your copy today!

THE PARKER-HARTFORD CORPORATION
FRANKLIN AVENUE HARTFORD, CONNECTICUT

New
POWER RESISTORS for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.

Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.
83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"

CIRCLE 161 READER SERVICE CARD

COMING MARCH 30th

THE ENGINEER'S BOOKSHELF

First published in March 1957, this highly popular report has been revised to include the many excellent references published during 1957 and 1958.

To the original list of more than 300 best references in 22 special fields have been added 150 reference books.

There are 20 basic handbooks that have qualified as "best buys" for the desk-side reference shelf. You will automatically receive this 16-page report, if you are a subscriber to Product Engineering on March 30th. Be sure not to let your subscription run out.

Or, if you don't now subscribe, send in your order today to:

Circulation Manager
Product Engineering
330 W. 42nd St.
New York 36, N. Y.

IT'S A **SNAP** with

LUCAS-MILHAUPT

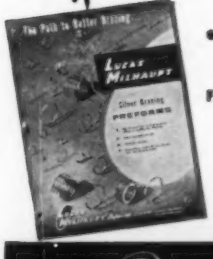
SILVER BRAZING PREFORMS

In addition to round and flat wire rings, blanked and edgewound washers, Lucas-Milhaupt provides a complete line of preforms which include such shapes as elliptical, rings, hinged rings, segments, slugs, U clips, hairpins, etc.

Send your drawings or sample part and the proper preform will be designed to do your brazing job faster at less cost.

Preforms in any size or shape that . . .

- End Wasted Time In Placing Silver Solder in position for brazing.
- Speed Assembly Work.
- Eliminate Rejects.
- Meter Silver Solder to Flow In and Around Joints.



FREE . . .

16 page booklet gives you all the facts on better brazing with preforms. Write Today!

LUCAS MILHAUPT
ENGINEERING COMPANY

5056 SOUTH LAKE DRIVE
CUDAHY, WISCONSIN

CIRCLE 162 READER SERVICE CARD

colored, and bronze exhibited a significant weight loss with some fluids.

Cast iron showed a slight weight loss; chrome molybdenum steel was relatively unchanged after the tests—it maintained its shiny, freshly polished surface and exhibited only minor changes in weight.

Appearance of copper-beryllium ranged from dull pink to dark brown in the test fluids. There was practically no change in weight. Lead appeared to be incompatible with all three test fluids. Stainless steel was unaffected; titanium was practically unchanged.

Statistics of Extremes

E I GUMBEL. Columbia University Press, 2960 Broadway, New York 27. 6 x 9, 200 pp. $15.

Up to recent times, statistics were applied by science primarily to the study of normal distribution, the behavior of mean values and frequent events. Yet, in many cases the norms and the means are of little importance; extreme values and the rare events are decisive. The present volume, a statistical study of extreme values, is an original contribution to the calculus of probabilities. In addition it includes mental studies by scientists working in different fields and in many countries.

The book is directed to statisticians and statistically minded engineers, geophysicists, and climatologists, who may apply the findings in science, industry and technology. Theories and equations may, for example, be used for calculating the endurance of metals.

High-temperature Alloys Melted and Precision Cast In Air and Vacuum

MILO J STUTZMAN. WADC Technical Report 57-678. PB1311807, Office of Technical Services, Dept of Commerce, Washington 25, DC. PB131807. 103 pp, 8¼ x 10¾. $2.50.

Two nickel base alloys, Utimet 500, and Guy's Alloy, and two cobalt base alloys, Stellite 31 and He 1049, were studied statistically to determine if vacuum melting improved mechanical properties. While vacuum drastically improved tensile and rupture properties of the nickel alloys, it improved ductility of the cobalt alloys but not their strength. With the Utimet 500, small amounts zirconium and boron added under vacuum increased rupture

(Continued on page 94)

TEXITE WHEELS-

IN *Any* SIZE

Now . . . for the *first time* you can have long wearing, easy rolling, floor protective Texite wheels *in any size!* Texite wheels are those tough, high capacity industrial wheels made of heavy, macerated canvas, impregnated with phenolic resin and press formed under high pressure and temperature. Immediately available in diameters from 3¼" to 16", tread widths from 1½" to 4" and capacities all the way to 8000 pounds. Plain, roller or sealed bearings.

Texite Wheels with Laminated Tread

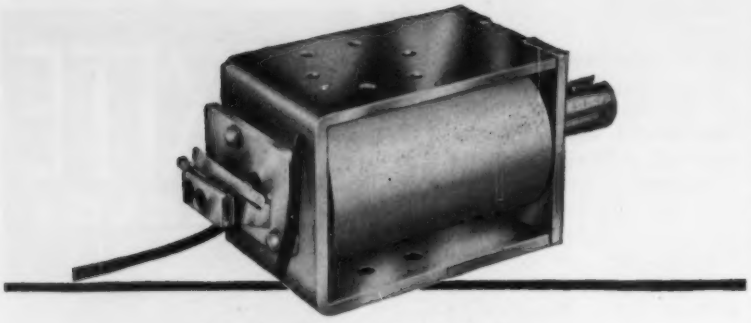
More durable than regular Texite, highly resistant to chipping or fraying. Shock or impact resistance is 35% greater and safe loading capacities are increased 25%. Available in same broad range of sizes as regular Albion Texite Wheels.

Big New '59 Catalog

Albion's big, new '59 Catalog of Industrial Casters and Wheels is ready for your use and convenience. Write for your personal copy—today!

ALBION INDUSTRIES, inc.
Albion, Michigan

CIRCLE 163 READER SERVICE CARD



Write for Engineering Bulletins on

PHILLIPS SOLENOIDS

Designed for industrial control applications where long life and reliability are prime requirements. A wide range of types and sizes.

Manufacturers of Sub-Miniature, telephone, power, general purpose relays — solenoids.

Phillips Control Corporation, Joliet 5, Illinois— AN ALLIED PAPER CORPORATION
SUBSIDIARY — SALES OFFICES: NEW YORK - PHILADELPHIA - BOSTON - SAN FRANCISCO - DENVER - SANTA MONICA - WASHINGTON - WINSTON SALEM - CLEVELAND - DALLAS - SEATTLE - KANSAS CITY - ST. LOUIS - DETROIT
CIRCLE 164 READER SERVICE CARD

FREE
416-PAGE CATALOG

Lists over 8,000 Precision Instruments, Parts and Components.

From stock! Complete with Drawings, Full Specifications and Prices.

FREE
14-Piece
"DESIGN-AID" TEMPLATE KIT

14 actual size templates, created to assist you in the design and development of specific mechanical systems.

Send for FREE Catalog and "Design Aid" Today.

PIC DESIGN CORP.
Subsidiary of BENRUS WATCH COMPANY, Inc.
477 Atlantic Avenue
East Rockaway, L. I., N. Y.

EMPLOYMENT OPPORTUNITIES

DISPLAYED RATE

The advertising rate is $31.20 per inch for all advertising appearing on other than contract basis. Frequency rates quoted on request.

UNDISPLAYED RATE

$2.10 per line, minimum 3 lines. Position Wanted ads in this style ½ the above rate. To figure advanced payment count 5 average words to a line.

ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.
NEW YORK 36: P. O. BOX 12
CHICAGO 11: 520 N. Michigan Ave.
SAN FRANCISCO 4: 68 Post St.

POSITION WANTED

Creative Industrial Designer. B.F.A. in Industrial Design. Five years employed by leading electronics manufacturer in design of consumer goods. Desires to join design group involved in commercial or military products. Particularly interested in human engineering. Has experience in production techniques of plastics, metals, wood. Can take design problem from concept to detail drawings. PW-9984, Product Engineering.

When Answering BOX NUMBERS . . .

to expedite the handling of your correspondence and avoid confusion, please do not address a single reply to more than one individual box number. Be sure to address separate replies for each advertisement.

strength even further. Unless you have specific interests in these test procedures for alloy development work, this booklet contains little property data not available elsewhere.

Effect of Surface on the Behavior of Metals

Published by Philosophical Library, 15 E 40th St, New York 16. 5½ x 8½, 100 pp. $10.

Compilation of papers presented at the 1957 Refresher Course for members of The Institution of Metallurgists. No direct design contents but useful for its fundamental information on metal behavior. The subject covered is basic mechanisms of how metal surface affects properties such as reflectivity, wear, electrical, magnetic and mechanical properties. Unfortunately overpriced. If offered in a paperbound edition for a lower price would have been valuable addition to one's basic library.

Current Reprints

While the supply lasts, single copies of the following reprints are obtainable by using the Reader Service Card.

Strain-testing by PhotoStress
Method to read strain in actual structures and parts under load. March 2 *Circle E 70*

Introducing the Space Crank
Variation of a 3-D mechanism that can replace various linkages and cams. March 2 *Circle E 69*

Stress Considerations for Safe Design
Graphical method determines safety factors when fluctuating loads are superposed on existing stresses. Feb. 16 *Circle E 68*

When Air is the Coolant
How to estimate whether the assembly will run too hot—and whether or not air can cool it. Feb 16 *Circle E 67*

For Faster Reading
Five steps to improve your reading speed—combined reprint of six-part article. *Circle E 66*

Linkages by Graphical Synthesis
Design of 4-bar linkages to generate specific functions. Feb. 2 *Circle E 65*

Product Design at —300 F
Planning for products that must handle liquefied-air gases. Feb. 2 *Circle E 64*

Solution by Analogy
What makes analog computers different from digital types? Jan 26 *Circle E 63*

(Continued on page 95)

Checklist of McGRAW-HILL books

☐ **CREEP OF ENGINEERING MATERIALS**

Just Out! Helps you solve creep problems in engineering. Covers creep mechanism, variables, and measurement; behavior in metals and nonmetals; and many more topics. **By I. Finnie and W. R. Heller. 327 pp., 126 illus., $11.50**

☐ **MACHINE TOOLS FOR ENGINEERS**

Just Out! Describes, analyzes, and evaluates all types of machine tools, showing engineers how they are used, what they can do, and what their limitations are. **By C. R. Hine. 2nd Ed. 435 pp., 362 illus., $7.75**

☐ **PLASTIC ANALYSIS OF STRUCTURES**

ust Out! Gives theory and methods that show how and when to apply plastic analysis for solving structural problems. Covers beams, plates, shells, slabs, etc. **By P. G. Hodge, Jr., 364 pp., 160 illus., $10.50**

☐ **COMPACT HEAT EXCHANGERS**

Just Out! A master reference of modern data and methods to help you design and analyze compact heat exchangers. Includes heat-exchanger solutions. **By W. M. Kays and A. L. London. 156 pp., 136 illus., $6.00**

☐ **ELECTRONIC DIGITAL COMPUTERS**

Just Out! Gives a comprehensive picture of the principles behind digital computing machines. Shows how basic circuits and devices are assembled and interconnected. **By C. V. L. Smith. 443 pp., illus., $12.00**

☐ **COATED ABRASIVES**

Modern Tool of Industry

Just Out! A ready-to-use reference for all manufacturers whose products require cutting, polishing, or finishing by means of abrasives. **Coated Abrasives Manufacturers' Institute. 422 pp., 543 illus., $8.50**

50 YEARS OF PUBLISHING 1909 1959 McGRAW-HILL BOOK COMPANY

See for 10 days free

McGRAW-HILL ON-APPROVAL COUPON

McGraw-Hill Book Co., Dept. PE-3-2
327 W. 41st St., New York 36, N. Y.

Send me book(s) checked below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents for delivery costs, and return unwanted book(s) postpaid. (We pay delivery costs if you remit with this coupon—same return privilege.)

- ☐ Finnie & Heller—**Creep of Engrg. Mat.**—$11.50
- ☐ Hine—**Mach. Tools for Engrs.**—$7.75
- ☐ Hodge—**Plastic Anal. of Struct.**—$10.50
- ☐ Kays & London—**Compact Heat Exch.**—$6.00
- ☐ Smith—**Electronic Digital Computers**—$12.00
- ☐ CAMI—**Coated Abrasives**—$8.50

(PRINT)
Name .....
Address .....
City ..... Zone .... State.....
Company .....
Position .....

For price and terms outside U.S. write McGraw-Hill Int'l., N.Y.C. PE-3-2

Current Reprints .....continued

Roll Cams—Stop and Go on Demand

Graphical method for designing simple mechanisms that give a prescribed motion when triggered. Jan 19 *Circle E 62*

Which Fhp Motor for the Job?

Applications and costs charted for a simpler way to pin down the right electric motor. Jan 19 *Circle E 61*

With What Do the Russians Weld?

Latest Soviet techniques—electro-slag, submerged-arc, and stored-energy welders. Jan 19 *Circle E 60*

Engineer Salary Surveys

Engineers Joint Council says engineer salaries are up 13% since 1956. GE reports effect of higher living costs. Jan 5 *Circle E 59*

Mixed-flow Impellers

When air pressure requirements are too high for axial and too low for centrifugal fans. Jan 5 *Circle E 58*

Carpet Plotting for Hi-temp Data

Data sheet shows interaction of stress, strain and temperature. Jan 5 *Circle E 57*

Gear Standards

Proposed all-inclusive standard for spur and helical, for both instrument and power service. Dec 22 '58 *Circle E 56*

Linkage Joints

Discussion of motions and factors leading to better joints. Dec 8 '58 *Circle E 53*

Swivel Joints

These basics will reduce trial-and-error in design. Dec 8 '58 *Circle E 52*

Springs that Store Energy Best

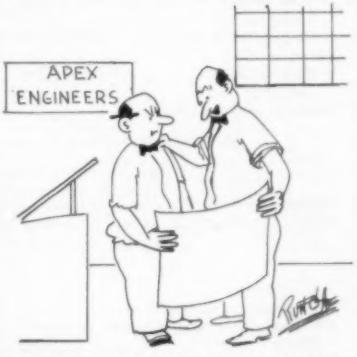
How shape and material govern efficiency; table compares 13 spring shapes. Nov 10 '58 *Circle E 48*

QUANTITY PRICES

For single shipments of any one title to one address on order accompanied by remittance, quantity orders will be supplied at the following prices as long as the supply lasts.

Quantity	*Price per Copy*
5	*$0.25*
25	*0.20*
50	*0.15*
100	*Write for quotation*

Make checks payable to PRODUCT ENGINEERING, 330 West 42nd St., New York 36, N. Y.



"All done, eh Hendricks? . . . That's fine, Hendricks . . . fine! Except . . ."

FOR SEALING THE UNUSUAL . . .

DURA SEAL

. . . provides mechanical sealing for the widest range of pressures, temperatures and speeds

Technical information on request — write **DURAMETALLIC CORP., Kalamazoo, Michigan**

INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Assemblies
Hydraulic 91

B

Bearings
Ball 31, 83
Roller .....4th Cover
Self-Lubricating 66
Belts, V 8-9, 68
Books 95
Brake Motors .....3rd Cover
Brakes
Electric 90
Brazing
Alloys 93

C

Cams 84, 88, 92
Carbon 36-37
Casters 93
Chains
Bead 88
Roller 11
Chemical Treatments 76
Clips 40
Clutches
Electrical 90
Mechanical 87
Coatings 76
Coils 78
Compressors 88
Connectors
Hose 17-18
Tube 17-18
Controls
Hydraulic 27, 80
Pneumatic 1, 27
Couplings
Hose 91
Tube 91
Cylinders
Hydraulic 27
Pneumatic 27

D

Deep Drawing 84
Die Castings 6
Drafting
Supplies 35
Drives
Adjustable Speed 73

E

Engineering Services (see also Production Services) 63
Engines 82

F

Fastening Methods.....40, 81, 85
Filters
Air 14-15
Fittings, Hose, Pipe & Tube 17-18, 29, 91
Forgings 16

G

Gear Motors (see also Motor Reducers) .....3rd Cover, 34
Gears 4, 81, 82, 86, 89
Graphite 36-37

H

Handles & Knobs 86
Hard Surfacing 86
Heating Units 92
Hose & Tubing 29

I

Instruments
Mechanical 94

L

Locks 85
Lubricants 76
Lubricating Equipment 14-15

M

Metal, Pre-Finished 78
Moldings
Plastics (see Plastic Parts)
Powdered Metal (see Powdered Metal Parts)
Rubber (see Rubber Parts)
Motors, A-C
Fractional 34, 42
Integral 42
Sub-Fractional 74
Motors, D-C
Fractional 34, 42
Integral 42
Motors, Hydraulic 98

N

Nickel Alloys 2
Nuts 85

P

Packings 82
Photographic Equipment
Film 35, 38
Pillow Blocks 31
Plastic Parts 84, 86
Plastics 90
Plastics Fabricated 84
Plastics Laminated to Metal..... 90
Porcelain 12-13
Powdered Metal Parts.....36-37, 66
Power Packs
Hydraulic 27
Power Take-Offs 87
Pumps
Liquid 91

R

Regulators
Pneumatic 14-15
Relays 94
Reproduction Supplies 35
Resistors 92
Rivets 74
Rod Ends 83
Rubber-Bonded-to-Metal 63
Rust Proofing 76

S

Screws 80, 92
Seals .....2nd Cover, 63, 82, 95
Seating Work Equipment..... 80
Sheets
Metal 78
Silver Alloys 93
Solenoids 94
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 40
Speed Increasers & Reducers..... 87
Spinning 84
Springs 32-33
Sprockets 11
Steel
Spring 30
Strip, Metallic 78

T

Thermostats 75
Timers 28, 77, 79
Tracing Paper 35
Tubing
Flexible Metal 29

V

Valves
Air 1, 17-18, 27, 70
Hydraulic 27, 70
Solenoid 70

W

Welding
Nuts 80
Wheels 93
Wire Cloth 10

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Albion Industries, Inc. 93
American Metal Hose Div., American Brass Co. 29
American Nickeloid Co. 78
American Steel & Wire Div., U. S. Steel Corp. 32-33
Anchor Coupling Co., Inc. 91
Auburn Mfg. Co. 82

B

Bead Chain Mfg. Co., Inc. 88

C

Cambridge Wire Cloth Co. 10
Chicago Rawhide Mfg. Co. ..... 2nd Cover
Chrysler Corp., Amplex Div. 66
Commercial Shearing & Stamping Co. 16
Cutler-Hammer, Inc. 28

D

Dayton Rubber Co., Industrial O.E.M. Div. 8-9
du Pont de Nemours & Co., (Inc.), E. I., Film Dept. 38
Durametallic Corp. 95
Dynamatic Div., Eaton Mfg. Co. 73
Dynamic Gear Co. 86

E

Eagle Signal Corp., Industrial Timers Div. 77
Electro-Flex Heat, Inc. 92
Eonic, Inc. 84

F

Fairfield Mfg. Co. 81
Fenwal, Inc. 75

G

Gear Specialties, Inc. 4
General Industries Co. 74

H

Hydronic Co., The 80

I

Industrial Timer Corp. 79
International Nickel Co., Inc. 2
Invo Spline, Inc. 82

J

Jones & Laughlin Steel Corp., Stainless & Strip Div. 30

K

Keuffel & Esser Co. 35

L

Lamb Electric Co. 34
Link-Belt Co. 11
Logansport Machine Co., Inc. 27
Lucas Milhaupt Engineering Co. 93

M

McGraw-Hill Book Co., Inc. 95
Masland Duraleather Co., The 90
Milford Rivet & Machine Co. 74
Milsco Mfg. Co. 80
Moore, Inc., George W. 92
Mt. Vernon Die Casting Corp. 6

N

Norgren Co., C. A. 14-15

O

Ohio Nut & Bolt Co. 80

P

Palnut Co. 85
Parker Fittings & Hose Div., Parker-Hannifin Corp. 17-18
Parker-Hannifin Corp., Parker Fittings & Hose Div. 17-18
Parker-Hartford Corp. 92
Parker Rust Proof Co. 76
Perkins Machine & Gear Co. 89
Phillips Control Corp. 94
Phoenix Products Co., Metal Spinning Div. 84
PIC Design Corp. 94
Porcelain Enamel Institute, Inc. 12-13
Precision Rubber Products Corp. 63

R

Reliance Electric & Engineering Co. ..... 3rd Cover
Reuland Electric Co. 98
Rockford Clutch Div., Borg-Warner Corp. 87
Ross Operating Valve Co. 1
Rowbottom Machine Co. 88

S

Sinko Mfg. & Tool Co. 84
Skinner Electric Valve Div., Skinner Chuck Co. 70
Stephens-Adamson Mfg. Co., Sealmaster Bearings Div. 31
Stephens-Adamson Mfg. Co., Spherco Bearings & Rod Ends Div. 83

T

Timken Roller Bearing Co. ..... 4th Cover
Tinnerman Products, Inc. 40

U

U. S. Graphite Co., Div. of the Wickes Corp. 36-37
U. S. Rubber Co., Mechanical Goods Div. 68

V

Viking Pump Co. 91

W

Wagner Electric Corp. 42
Wall Colmonoy Corp. 86
Warner Electric Brake & Clutch Co. 90
Waterbury Companies, Inc. 86
Waukee Engineering Co. 88
Wisconsin Motor Corp. 82

PRODUCT ENGINEERING ADVERTISING SALES STAFF

Atlanta 3 . . . W. O. Crank, 1301 Rhodes-Haverty Bldg., Jackson 3-6951

Boston 16 . . . M. A. Williamson, Jr., 350 Park Square Bldg., Hubbard 2-7160

Chicago 11 . . . Mid-Western Adv. Sales Manager, A. E. Meaner; R. W. Bruley, L. Anderson, 520 N. Michigan Ave., Mohawk 4-5800

Cleveland 13 . . . A. F. Tischer, 1164 Illuminating Bldg., 55 Public Square, Superior 1-7000

Dallas 1 . . . R. T. Wood, 901 Vaughn Bldg., 1712 Commerce St., Riverside 7-5117

Denver 2 . . . John W. Patten, 1740 Broadway, Mile High Center, Alpine 5-2981

Detroit 26 . . . P. B. Robinson, 856 Penobscot Bldg., Woodward 2-1793

Los Angeles 17 . . . Robert Obenour, 1125 West 6th St., Madison 6-9351

New York 36 . . . B. K. Adams, J. C. Taney, R. G. Wallace, 500 Fifth Ave., Oxford 5-5959

Philadelphia 3 . . . D. G. Jones, K. S. Wiladson, 6 Penn Center Plaza, Locust 8-4330

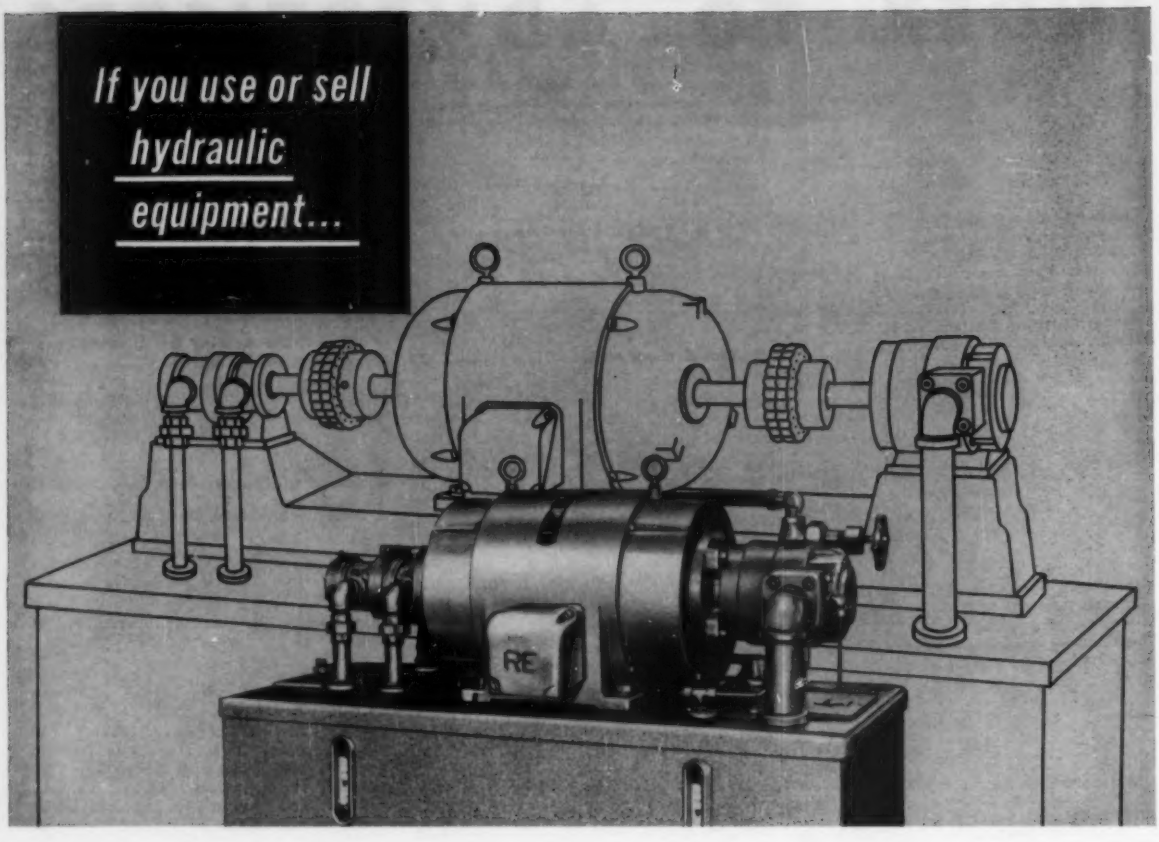
Pittsburgh 22 . . . C. F. Lavereni, 1111 Oliver Bldg., Express 1-1314

St. Louis 8 . . . R. W. Bruley, 3615 Olive St., Continental Bldg., Jefferson 5-4867

San Francisco 4 . . . W. C. Woolston, 68 Post St., Douglas 2-4600

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 94
Index to Advertisers begins on P. 97
Products Index begins on P. 96



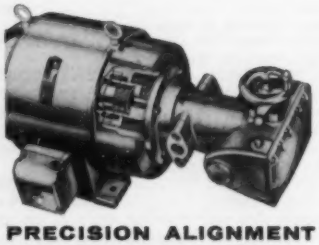
...specify REULAND spline-coupled pump mount motors

...CUT SPACE NEEDS ALMOST 50%...AVAILABLE *NOW* IN ½ H.P. THROUGH 50 H.P.!

Pump and motor become *one* with the new Reuland spline-coupled hydraulic pump hook-up. The pump shaft is connected directly to the motor's shaft *inside the motor.* Flexible couplings are eliminated... pump mount platforms are eliminated... and the tank length can be reduced because almost 50% less mounting area is required. Compact appearance is beautiful.

SPEEDY INSTALLATION

Pump-to-motor hook-up is merely a matter of seconds. All you do is slip the spline coupling onto the pump shaft...and attach the pump to the endbell. This spline coupling is supplied with the motor and is precision mated for each make of pump. There's no time wasted tinkering around... takes only a fraction of the ordinary time.



PRECISION ALIGNMENT

Alignment is perfect *automatically* whether the installation is made out in the field or on the production line. This permits even unskilled workmen to handle this simple task without error. Also, by hooking the pump up at the point of bearing support, within the motor, vibration is reduced to a new minimum. Operation is smooth, quiet.

COSTS LESS...SAVES INSTALLATION LABOR... FITS ALL PUMPS...FILLS ALL POWER NEEDS—

½-50 H.P. The Reuland spline-coupled unit is priced lower than a conventional set-up ... saves you extra money by reducing installation costs. What's more, we can supply it to fit any make of pump you may be using... and to your *exact* power needs, from ½ h.p. through 50 h.p. So sure are we that it will be of help to you, we are offering to engineer a demonstration unit to your equipment, without the slightest obligation. These units are our best salesmen.

Our New General Catalog Will Come in Handy—Sent Free on Request.

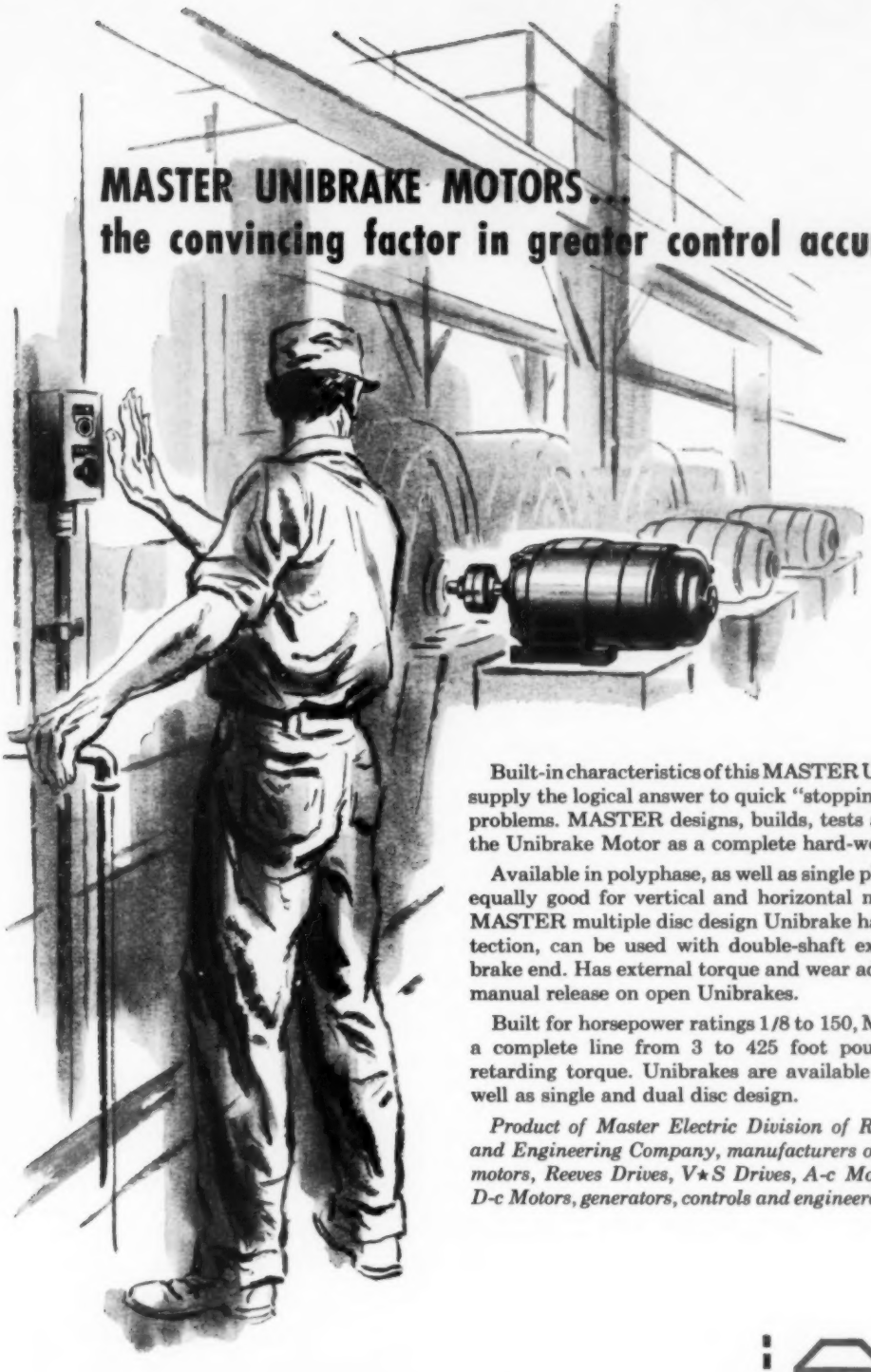
MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY
WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

*Trademark Registered

MASTER UNIBRAKE MOTORS...
the convincing factor in greater control accuracy



Built-in characteristics of this MASTER Unibrake Motor supply the logical answer to quick "stopping and holding" problems. MASTER designs, builds, tests and guarantees the Unibrake Motor as a complete hard-working *unit*.

Available in polyphase, as well as single phase and d-c.—equally good for vertical and horizontal mounting—this MASTER multiple disc design Unibrake has fail-safe protection, can be used with double-shaft extension at the brake end. Has external torque and wear adjustment, plus manual release on open Unibrakes.

Built for horsepower ratings 1/8 to 150, MASTER offers a complete line from 3 to 425 foot pounds maximum retarding torque. Unibrakes are available in multiple as well as single and dual disc design.

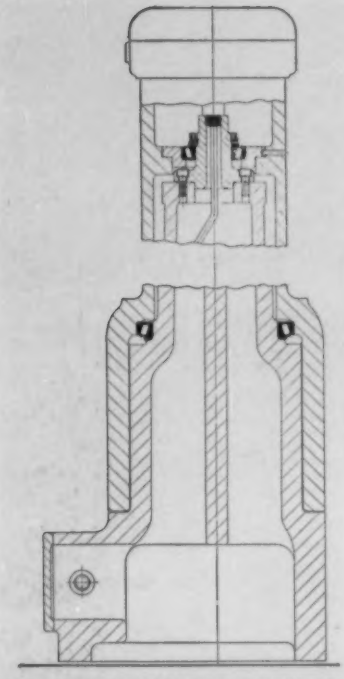
Product of Master Electric Division of Reliance Electric and Engineering Company, manufacturers of Master Gearmotors, Reeves Drives, V★S Drives, A-c Motors, Super "T" D-c Motors, generators, controls and engineered drive systems.

B-1614

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 303A CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in Principal Cities

MASTER R REEVES



How **THE AMERICAN TOOL WORKS CO.** mounts column of 32-speed Hole Wizard Radial on 2 Timken bearings to increase rigidity 50%. Spindle and transmission use 11 more Timken bearings.

This radial drill has 50% more rigidity with column mounted on Timken® bearings

TO resist stresses and cut arm deflection in half, the column unit of this 32-speed Hole Wizard Radial is mounted on two Timken® tapered roller bearings. With a large, preloaded Timken bearing at top and bottom, The American Tool Works Company gives the column and sleeve the rigidity of a single piece. This results in greater accuracy and longer cutting tool life, permits higher speeds and coarser feeds.

HOW COLUMN IS HELD RIGID. Timken bearings keep the column unit in positive alignment. Their tapered design lets them take both thrust and radial loads in any combination. And full line contact between rollers and races gives Timken bearings load-carrying capacity to spare.

HEAVY SHOCKS ABSORBED. Rollers and races of Timken bearings are case-carburized to give them hard, wear-resistant surfaces over tough, shock-resistant cores. They reduce maintenance.

FRICTION VIRTUALLY ELIMINATED. Timken bearings run smoother, last longer, because they're geometrically designed for true rolling motion—and precision-made to live up to their design. We even make our own electric furnace, fine alloy steel—the only American bearing maker who does.

So whether you buy or build machines, it pays to specify bearings trademarked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.